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# Metal Progress

American Society for Steel Treating

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**Ernest E. Thum, Editor**

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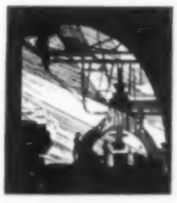

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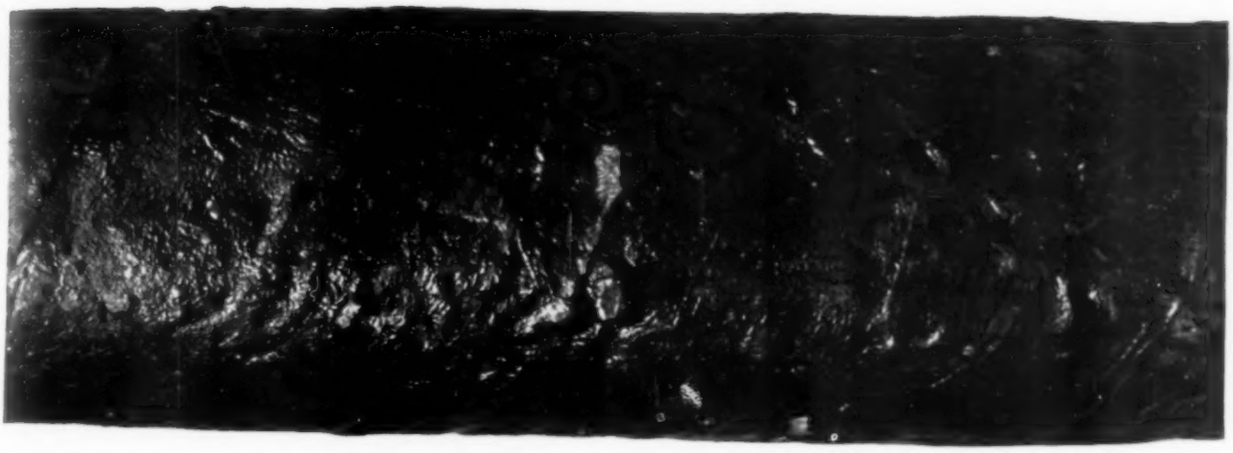

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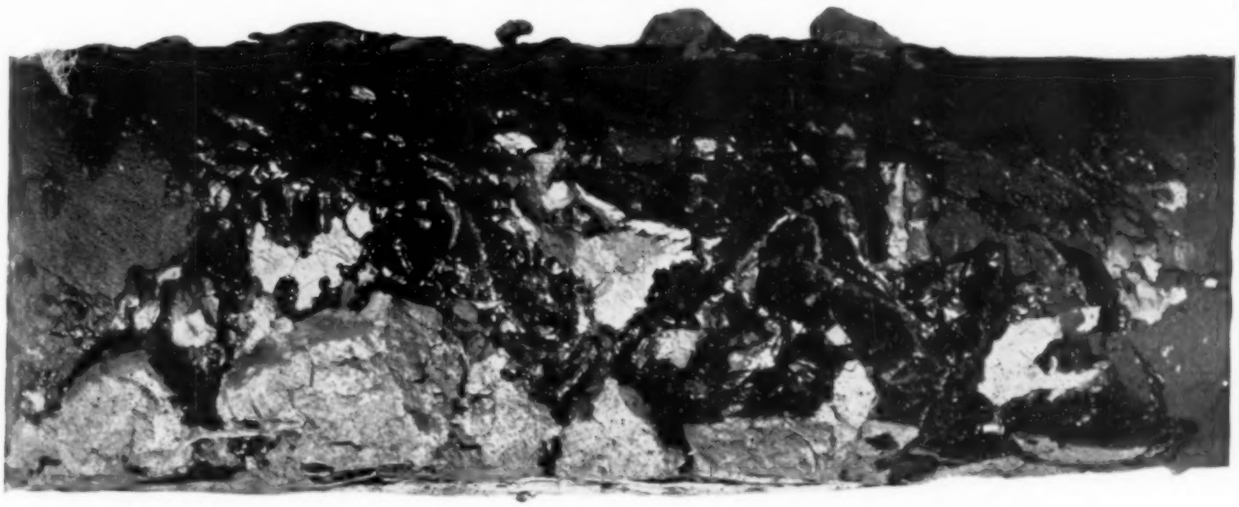
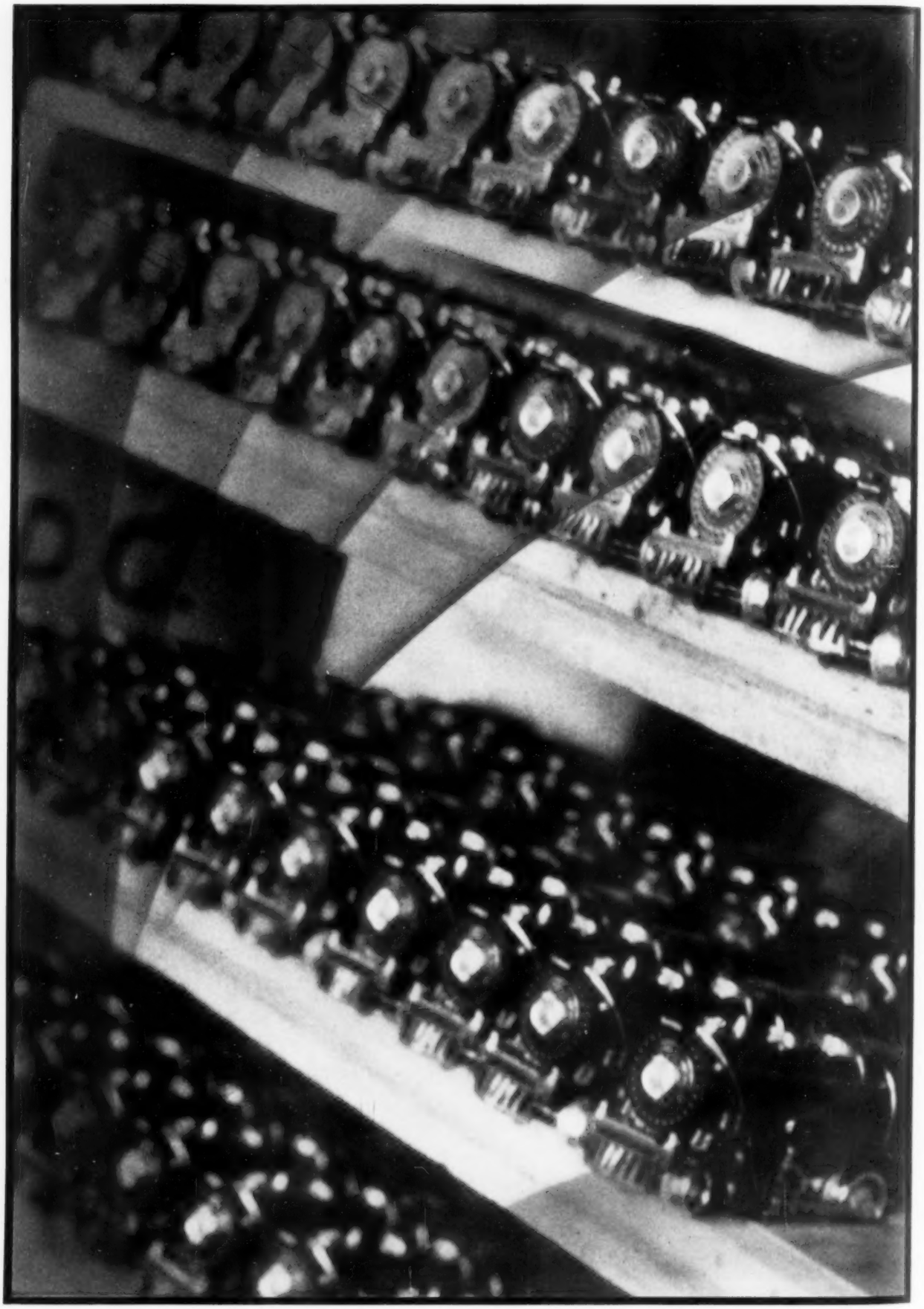




# Metal Toys . . . Look Real

by John Mapes

A BAG filled with representative American-made toys would be a load for a husky football player. To a little, fat, old man like Santa, it would be overwhelming, for metal toys are very popular now. Cast iron, sheet steel and lead alloys are the most important of the metals used in the toy industry, although tin, aluminum and many others have their place.

Convinced that children of today want realistic playthings, the makers of certain types of metal toys spend many hours and dollars to make and produce model automobiles, locomotives, and sets of dollhouse furniture that closely resemble real automobiles, locomotives or furniture. Another important line contains steel parts which can be assembled in bridges, skeleton structures and construction equipment.

In some toys it is not difficult to attain realism — in automobiles, for instance, where both the original and the toy are made of metal. Household furniture, with but a few exceptions, is still made of wood and fabric, but despite this handicap, toy furniture makers have succeeded in putting out a product made of metal, looking enough like real furniture to please the children, low enough in cost to please the parents, and easy enough to make in quantity to please themselves.

Sturdy, prosaic, gray cast iron makes remarkably realistic little automobiles and furniture sets. The Arcade Manufacturing Co. at Freeport, Ill., is adept in the magic of transforming iron into attractive toys. The magic consists chiefly of excellent foundry practice and a good knowledge of child psychology.

As might be expected, when toys are made of cast iron, the individual castings are frequently very small and have thin sections. A very fluid iron is necessary and the composition of the iron used at the Arcade plant calls for a minimum of 2.50% silicon, and at least 1.0% phosphorus. Special molding machines designed by the company's engineers are used to make the green sand molds, and have proved so successful in their own plant that they are made for general sale.

Ten tons of iron per day represent the maximum capacity of this foundry, but the small tonnage is no indication of the vast number of castings produced in a single day. Each molding machine can make between 200 and 250

coreless molds per day, and there are 60 of these machines in the foundry, nearly all of them in operation now. While the busy season of toy manufacturers runs from the beginning of summer until the first of December, the manufacture of toys is a 12-month per year business. Production of new models commences early in the year, and toy plants generally are reporting an excellent production, despite the generally depressed condition of the metal industry.

After the castings are made, they are tumbled and cleaned in a single operation. A battery of tumbling barrels containing water, sand and soda ash can put an excellent rough finish on the most intricate of castings and all except the most fragile are cleaned in this way if either nickel or silver plating is to follow. When the castings are to be enameled, they are tumbled for a shorter period in ordinary tumbling barrels with cast iron stars or toy jackstones.

Jackstones, by the way, have not become passé with the advent of the high speed toys of the present generation of children. Over 25,000,000 jacks have been made at the Arcade plant so far this year. They serve their term in the tumbling barrels and then are nickel plated or enameled in some bright color for sale to jobbers

*Cleverly Designed Jigs Speed Spot Welding. When automobile frames and bodies are so assembled, as at the Buddy "L" plant, jigs are essential to efficiency. This one is for welding the hood to the cowl of a dump truck.*

either in bulk or in packages.

Arcade products designed for small boys include about 40 models of passenger automobiles, trucks, and farm implements. Most of these are made entirely of gray iron; if the toy requires two or more parts, these are riveted together with copper, although 10,000,000 stampings are used in an ordinary year to finish certain items. Children in the farming districts can operate a model farm with such model toys. Several sizes of threshing machines, two types of manure spreaders, a harvester, models of two of the most famous ploughs, cream separators, and other agricultural appliances are among the best sellers.

City children are delighted with accurate reproductions of the automobiles they see on the streets, the big, cross-country buses, various kinds of commercial trucks and, of course, the ever-popular models of fire-fighting equipment such as hook-and-ladders, steamers, and hose carts.

Small girls, whether dwellers on the farm or in city apartment houses, love to have Santa leave them a set of model furniture. They can furnish a music room with a grand piano whose top opens and whose keyboard cover may be lifted or closed; with a model radio whose dials turn and whose paneled doors swing; and with a chaise longue which, although cast iron, looks remarkably like the best grade of upholstered furniture from a grown-up's store.

### Famed Trade Marks Reproduced

In the toy kitchen, for instance, they can have their choice of gas or electric ranges with oven doors that open and close. The kitchen cabinet is furnished complete. The sink has real faucets and, if desired, can have an electric dishwashing machine attached. Best of all, most of the toys carry the trade mark of some leading manufacturer of real equipment. Boys can truck sand and stone in Mack trucks with the familiar Mack monogram on the front, and girls can use tiny Thor washing machines. As a matter of fact, many American toys are modeled directly from blueprints furnished by the manufacturers of the original.

Cast iron toys are either plated with nickel or are given a coat of baked enamel. Where it is essential to reproduce the coloring of the original, this, of course, is done. But where the particular color is not of vital importance, red is most frequently used. It has certain sales power that blue and yellow cannot approach.

Sheet steel forms the basis of larger toys for children well past the nursery age. They want things so big and strong that they can get on and ride in them, play engineer, or drive a car "just like Dad." Steel with welded joints is about the only material which can stand the abuse heaped upon a handy-wagon by young America.

Eight years ago, Fred A. Lundahl, a manufacturer of auto fenders in East Moline, Ill., built a toy express truck for his 7-year old son, Buddy. Buddy liked the truck; all of Buddy's friends liked the truck even better. So Mr. Lundahl made some more out of scrap from his fender business, to take the scrap out of his neighborhood. Today Mr. Lundahl is still mak-

ing steel toy automobiles, but has dropped the manufacture of fenders. The business of making toys has grown so great that the former sideline has become his only work. The line bears the name, Buddy "L," in honor of the son who was the first to appreciate his father's genius as a toy maker.

Buddy "L" is exclusively a boy's line. There are automobiles of various kinds, trucks, fire engines, and so on, and there is also a line of machinery which includes concrete mixers that really can mix and pour concrete; ditch diggers which will dig a ditch one inch wide and six inches deep; and an efficient sand screener and loader. Then, of course, there are several models of steam shovels and dredges. An ambitious boy with the complete line of Buddy "L" toys can build a model concrete highway over which his toy automobiles can run smoothly.

These toys are made principally from fender stock of 18, 20 and 22 gage. Rear axles are of $\frac{1}{4}$-in. cold rolled steel, while the steering knuckles are drop forged like those for a real automobile. About 110 blanking and forming press operations are required to build a dump truck approximately 2 ft. long. The body assembly is spot welded; wheels are riveted together, and steering wheel is brazed to the steering rod. Thirty different parts go into one of the dump trucks, and jigs are used extensively for both welding and drilling. The shop equipment consists of 22 presses and 21 spot welding machines, and these are all busy during the high point of the toy maker's year. About 100 workers spend all their time supplying the boys of this country with rugged reproductions of grown-ups' machinery.

When assembly is completed, the toys are cleaned in a continuous machine which washes and then rinses them thoroughly to remove oil and grease, and then are dried in a steam room. Two coats of enamel are applied, and the toy is baked in gas-fired ovens heated to 600° F. The scars left by the spot

*Cast Iron Trucks Are Hand Dipped Into Enamel. This efficient method would hardly do for real trucks. Below is the conveyor assembly line where the truck parts are riveted together.*

welding machines are hardly noticeable in the finished product. Because of the materials and method of construction, Buddy "L" toys are unusually strong and the youngster can sit on them if he wishes without danger of anything happening. And if father should step on one in the dark, he might hurt his toe, but the toy will not suffer.

In such toys as Buddy "L" manufactures, machinery which actually operates is much to be desired. Consequently, the maker must pay a good deal of attention to the accurate fitting of moving parts. With few exceptions, however, the gears used in manually operated toys are stamped from heavy strip steel, as it has been found that after burrs have been ground off, these gears are more than adequate for the purpose. More precise work is necessary for motor-operated or solenoid-operated devices.

Sheet steel is also the most important raw material used at the Metalcraft Corporation, of St. Louis, which annually produces thousands of tricycles, skooters, model airplanes and other metal toys. This plant might almost be said to have standardized on 20-gage fender stock, which is purchased in scrap form, although a good quality of aluminum strip 0.06 in. thick and some tin plate of approximately the same thickness are built into some toys. Punch presses, 26 of them, are used in turning out the Metalcraft line. Other machinery includes a screw machine, five spot welders, one butt welder and a small hand mill for making tube out of the 20-gage stock.

### Skooters Easy to Build

More than 200,000 skooters, an article which most toy manufacturers recently decided was out of date, were built and sold last year by this St. Louis plant. The floor board is stamped out in one piece. The rear wheels are suspended by two triangular stampings which are welded to the floor board. The front wheels are attached to the pivoting steering bar which extends through the floor board high enough to be conveniently within reach of the child's hands. A pair of handlebars completes the skooter. As might be imagined, this little machine is quite easily manufactured, consisting as it does of a comparatively small number of press products spot welded rapidly together. The skooter, minus the wheels and handlebars, is painted one color, the wheels are painted another, and the handlebars are nickel plated.

*Riveting the Front Axle to the Main Frame. Buddy "L" steering knuckles are drop forged, like those of a real car.*

Aluminum was first used in quantity in 1929 when all-metal airplanes were introduced. The model plane which Metalcraft designed is an excellent reproduction of the Ford all-metal tri-motor monoplane. It proved so popular that 130,000 were built and sold last year.

One of the most up-to-date sections of the plant is the paint shop, which is entirely mechanical in operation. Series of conveyors bring parts through the painting room, dip them in an appropriate vat of color, and then pass them through a continuous oven for drying and baking. The only manual operations required are hanging the parts on the conveyor hooks and removing them when the baking is completed. Three carloads of toys can be painted and dried daily in a variety of colors by this equipment.

Even though the raw material coming into this toy shop is scrap fender stock, a constant study is made in the effort to minimize the scrap

left from the various blanking operations. Until spring of this year, two carloads of scrap per week were left after disk wheels for the skooters and tricycles had been blanked.

Along came miniature golf, however, so the alert management capitalized on the country-wide craze by turning out a Tom Thumb set for home use. Nearly all of the hazards so dear to the "play golfer" are formed directly from scrap remaining after wheel disks are cut. After enameling, this "scrap" is ready for sale at a price which brings the product within the reach of everyone. Now, instead of two carloads of such waste metal having to be sold weekly at the usual prices for such material, less than a carload is accumulated in two weeks.

A recently added toy is a set of knock-down freight cars for model trains. It consists of a number of cadmium plated sheets cut to a size and shape to permit bolting them together into model box cars, flat cars, and cabooses. These freight car sets are made entirely from scrap from other operations in the plant, and are formed by punch presses. Cadmium plating is done in the very complete plating room of the plant, which has a 5,000-lb. daily capacity.

Mention has already been made of a mill for rolling tube from 20-gage strip. This tubing is used rather extensively in the tricycles made by the company, since it has found it much cheaper than commercial tubing, and the product is equally good. In six passes the strip is curved and curled into a tube. The tube is then set in jigs and welded on a butt welding machine. A slight seam is visible, but does not detract from either the strength or appearance of the finished product.

Dowst Manufacturing Co. in Chicago daily produces thousands of 2-in. leaden models of trucks so well designed that they have been photographed for the national advertising of a leading truck manufacturer and so inexpensive that the civic budget of many communities permits their use as models for restaging traffic accidents in court cases.

Airplanes, automobiles and trucks comprise one line of toys made by this company. Toy furniture in metal is the other. In this second group are included tiny beds, tables, lamps, refrigerators, and bath tubs.

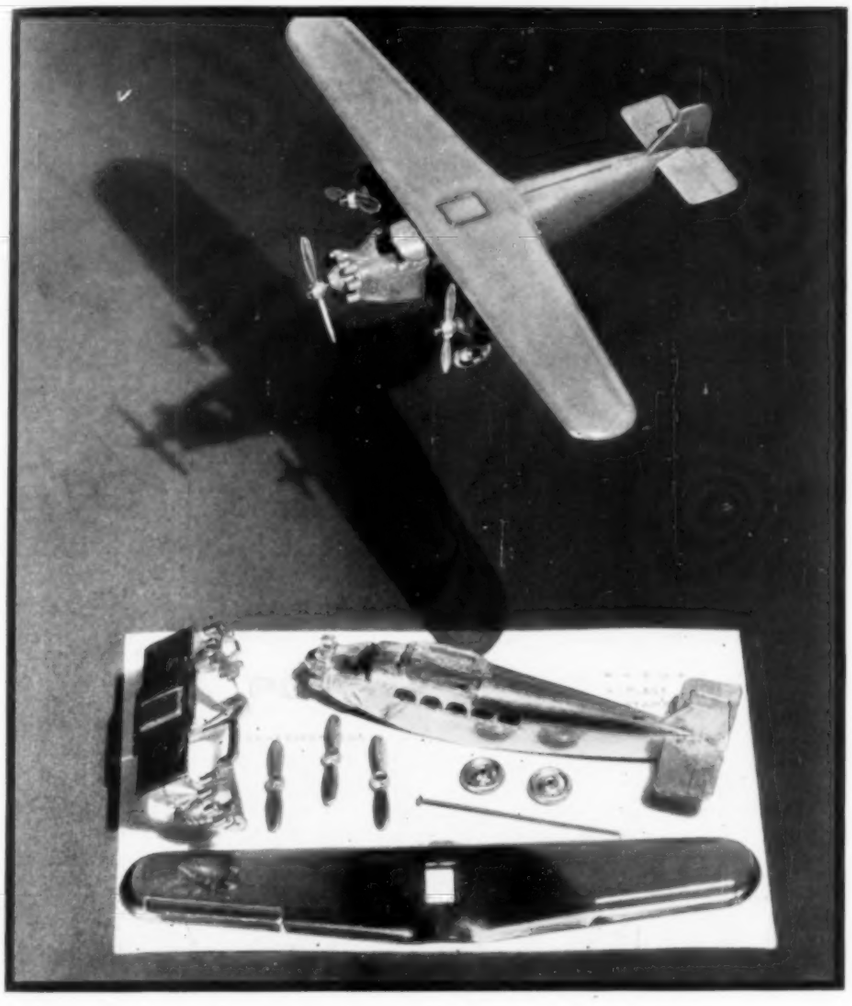
All of the Dowst toys are die cast from an alloy of lead, tin and antimony, and are produced in quantities during the 12 months of the year. Nothing but toys is made in the large, four-story building of the company.

The alloy closely resembles linotype metal in composition and has been found excellent for die casting because of its fluidity at low temperatures. The dies used are sunk from 0.30% carbon hot-rolled steel which, after sinking, is carburized. The sinking operation in itself is simple, consisting as it does of impressing a tool steel master model into the die under an 800-ton press. Some hand finishing and machining is necessary, of course, but most of the time-consuming work is eliminated.

The die casting department consists of about 50 mechanically operated high speed machines. The castings are, of course, all small, as the largest toy made at this company is only about 4 in. long. Gating is obviously a problem requiring much study because of the small sections cast. Many of the dies produce two or more pieces at one operation.

The various parts of any particular toy are assembled by means of small copper rivets. Stampings are used with die castings in some of the pieces, and these are made within the plant except those which are bought lithographed for use in the less expensive toys.

Colors are sprayed on while the toys are suspended from racks. It has been found that this is the best way of producing a good appearance on a multitude of small toys. An ingenious combination of paints is used to give an up-



*Parts Of A Die Cast Airplane. This model has a wingspread of 4½ in. but is composed of seven die cast parts, one stamping and a small brass pin. The fuselage and motor assembly are each single castings while the three propellers and two wheels are cast together.*

holstered appearance to certain of the furniture models. A flat coat, light in color, is first sprayed on and allowed to dry. A darker enamel is next applied which shrinks as it dries, leaving a cracked, two-color finish not unlike upholstery. Couches, over-stuffed chairs, and similar pieces are finished in this way.

All the wheel toys thus far described are hand operated, but the Lionel Corporation at Irvington, N. J., makes electric trains which need only the touch of a boy's finger on a rheostat to send them scurrying over metal track.

Many metals go into the manufacture of these locomotives, cars, track and accessory equipment, but sheet steel is the largest item. The sheet used is deep drawing quality, full finished, automobile sheet, of 22 and 26-gage. Much cold rolled strip, bought in the soft or half-hard condition, is also used in several thicknesses. The rails are of prime tin plate approximately 26-gage, clinched to pressed steel ties. Such a track unit will easily support the weight of a 300-lb. man.

Locomotives need weight to develop tractive effort and consequently, the main frames are stout zinc-base die casting or of counter weighted pressed steel. The driving wheels are die cast with a ferrule of nickel plated cold rolled strip pressed over the tread to avoid wear.

Brass, aluminum and copper also have various applications in the Lionel toy railroad system. A stainless steel shoe is the contact between the locomotive and the third rail, this expensive alloy being used because it resists pitting from electric sparks, and frictional wear.

In Lionel toys, realistic effects are gained from good designs and studied engineering, as may be seen from the frontispiece which shows a group of Lionel steam-type locomotives.

It would be unfair to give the impression that wheel toys and model furniture are the chief products of the metal branch of the toy industry. The industry is large and it is progressive. That those who manufacture metal toys rank among the most important of the toy makers is a tribute to their alert ability.

# High Frequency Induction Furnaces . . . . for making tool steel

By J. A. Succop

ACCEPTANCE of the Ajax-Northrup induction type of electric furnace by American tool steel manufacturers has caused a change in the methods of production which rivals in importance that caused by the adoption of the arc-type electric furnace several years ago. The first of these new induction furnaces used for making tool steel ingots in the United States began operations in September, 1928. Since then there have been several additional ones put into operation and others are now in process of erection. The adoption of this type of furnace has been rapid because it satisfies a number of requirements and offers many attractive advantages.

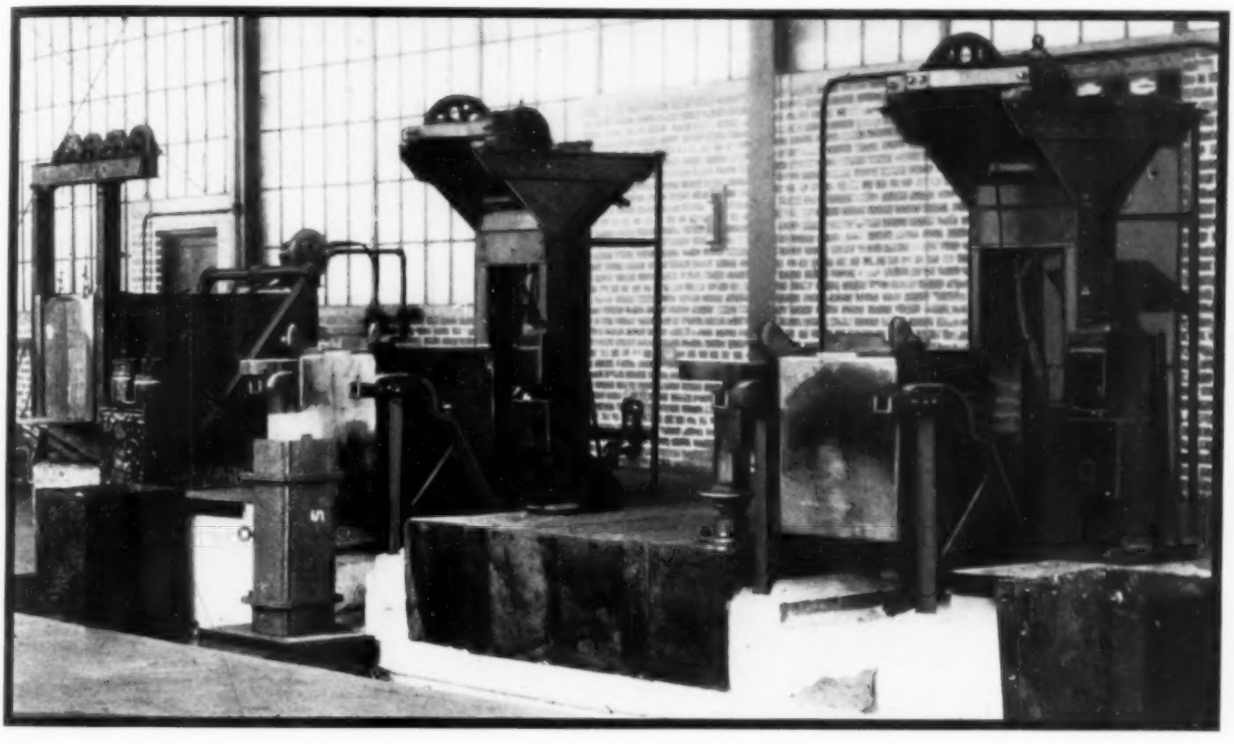
Plant conditions and the types of steel to be melted usually determine the advisability of its selection. Circumstances in one plant might favor rapid melting, small heats, and comparatively small ingot sizes. When such conditions exist, certainly the induction furnace is a most desirable tool. Many other plants, taking advantage of lower power rates, melt all their steel at night. It has been found that the induction furnace lends itself to intermittent operation more economically than the arc furnace. Plants where scrap of high alloy content is being remelted utilize the induction furnace for this purpose because the heats come through with lower oxidation losses.

Comparative power costs favor the arc furnace slightly, but it is quite possible that a large induction furnace kept in constant operation and melting steels similar to those being melted in an arc furnace in the same plant might equal the electrical consumption of the arc furnace in kilowatt-hours.

By a large induction furnace is meant a furnace with a capacity of one ton or more, with current derived from a 600-kw. motor generator set. This would provide sufficient energy for one-hour melting cycles. It should be noted that the preparation of the charge has a great bearing on the melting efficiency of the induction furnace; a few minutes extra care in securing a compact charge with good electrical contact means much in keeping the electrical consumption at a minimum.

The problem of refractories is one which is more difficult in the operation of the induction furnace than in the more conventional arc fur-

naces. Crucibles of clay and graphite have been known to give only 15 to 20 heats, but recently newer methods of patching and relining magnesia crucibles have made it possible to obtain over 300 heats per crucible. Successful results have also been obtained from sintered linings of different refractories — zirconium should be mentioned in this connection. The analysis of the steel being made has, of course, much to do with the type of refractory which can be used and the life of any crucible depends largely on the tapping temperatures and the length of time which heats are held in the molten condition. Erosion of the refractory appears to be a less difficult problem than the expansion and contraction which occurs in the lining during the cycle of each heat.



*A Pair of Ajax-Northrup Induction Furnaces in the Heppenstall Company's Plant. Ingot molds are set on small car running on depressed track.*

### Linings No Limitation

It was originally feared that it would be so very difficult to obtain and secure a satisfactory lining that the size of the induction furnaces would be sharply limited in practice, but it is now apparent that crucibles up to at least three tons capacity can be used satisfactorily.

From the standpoint of maintenance, the mechanical and electrical parts of the Ajax-Northrup furnace give no trouble. The motor generator set requires normal care and attention but otherwise the furnace equipment is not difficult to keep in good operating order. Of course, electrodes with their attendant evils are eliminated. Furnaces thus far installed are of a size that the molten steel can be poured through a funnel or tun-dish direct from the furnace into the ingot mold, as is shown in the view on page 42, thus eliminating the ladle. Much can be said about the desirability of such a practice; however, it has been found that ladle pouring is more satisfactory for very small ingots, say 1 in. square and smaller.

As for chemical and metallurgical considerations: The induction furnace has its points of superiority and also its disadvantages. Alloy recoveries have been mentioned previously, and this is a frequent use to which the induction furnace will be put — namely, remelting stainless and other highly alloyed scrap. Nickel, chro-

*Crane at Rear of Furnace Tilts the Casing About a Pivot at its Upper Front Corner and Metal is Poured Direct over Lip of Furnace.*

mium, tungsten, molybdenum, cobalt and vanadium, occurring in those percentages normally found in stainless and high speed steels, are recovered with very little loss on remelting.

Another distinct advantage of the induction furnace is the fact that very close control can be exercised over the chemical composition of the metal produced in it. If charges are kept consistent, very uniform chemical analyses from heat to heat can be maintained. The speed of melting and tapping prevents preliminary testing, so that the necessity for unusual care in making up the charges is apparent. European practice, which was adopted by most tool steel manufacturers in this country, uses for a base a high grade iron melting bar, with Swedish pig iron. If this practice is adopted, the plant can work to very close limits on all elements. Alloy recoveries are constant on a given grade of steel, so that the most complex analyses can be made repeatedly with very slight variation between the maximum and minimum percentage of any element recovered on a run of several heats. However, it should be again emphasized that in order to procure this delicate control, most careful weighing and most accurate analysis of the charge materials are necessary.

### Easy Temperature Control

Another good feature of the induction furnace which is proving of great assistance in the casting of alloy tool steels is that temperature is under easy control. It is easy to observe the heat through an optical pyrometer, accurate data can be secured, and it is also an easy matter to heat or cool a bath to within a few degrees of a desired tapping temperature. Regulation of the power input is sufficiently flexible to provide rapid or gradual changes in temperature.

Insufficient work has been done on a production scale to determine definitely what reactions can be accomplished by making up definite slags. Unless heat is applied externally, reactions between slag and metal probably cannot be so effective as in an arc type, because of the fact that under normal conditions the slag is heated only by radiation from the steel. Claims, based chiefly on laboratory experiments, have been made stating that phosphorus and sulphur can be reduced to low limits, but the economy and efficiency of this operation as conducted in the induction furnace may well be doubted.

However, deoxidizing slags of low melting temperature can be used very effectively. In this practice, the melting slag is usually removed, the new slag added and the steel heated to a temperature slightly over that desired for tapping. Power is then turned off and the metal held quiet until tapping. Treatments such as this add approximately five to seven minutes to the duration of a heat, which would otherwise require one hour for melting and tapping.

### Hot Bath Vigorously Stirred

On the other hand, the slag reactions are facilitated by the stirring action which characterizes an induction furnace bath; this action is so strong that the top of a bath 16 in. diameter can be raised in a cone so that the center is two or three inches higher than the outer portions of the bath. This stirring action results in each particle of steel being rotated and brought into contact with the slag on top. In recent furnace installations where it is desired to refine steels by slag treatments, arrangements have been made to regulate the violence of the stirring action without changing the total power input; in other words, the stirring action can be regulated independently and without changing the furnace temperature.

The stirring action is probably more valuable for causing a rapid and uniform distribution of alloys. Elements such as tungsten in high percentages are known to be distributed very evenly throughout an induction furnace bath. This feature not only prevents the loss of such elements of high specific gravity due to settling on furnace bottoms, but it also assists in producing a melt of uniform composition so that any segregation appearing in the finished steel is due entirely to ingot solidification.

Inasmuch as all portions of the molten bath in an induction furnace are within the top and bottom of the coil, heat is applied uniformly to all parts of the bath. This characteristic has overcome many very difficult problems which are furnace operators have had to face due to the "layer effect" in the baths.

It has also been found that low-carbon alloy

steels of stainless and other analyses are produced with greater ease in the induction furnace because there are no carbon electrodes to introduce this element into the bath. Furthermore, the carbon present in the original charge can be reduced to low percentages by the addition of ore and also by bessemerising with a hot air blast. But once again it should be said that most of the experimental work on this problem has been laboratory work, and, as far as is known to the writer, no method of this sort has been worked out and put into satisfactory practical application.

### Broad Claims Yet Unproven

Many very broad claims for induction steels have been made by some makers. Originally it was believed that its manufacture was a more or less fool-proof operation, but certainly such has not been found to be true. Great care must be exercised in the melting operation; dirty steel can come out of an induction furnace just as it can from any other melting operation if it is done improperly.

It is perhaps too early to make any definite claims for superiority, but it has been found by some plants having experience with both arc and induction furnaces that steels from the latter appear to be more consistently free from segregations of non-metallic inclusions, as disclosed by microscopic examination and by deep etching. In one place where such direct comparisons have been obtained, the steels have been cast into the same sets of ingot molds and have received the same forging, rolling, and annealing treatments.

While the induction furnace has definitely demonstrated its value in the melting of quality tool steels, it is nevertheless passing through a transitional period. Operators are varying the furnace practices and making additional experiments looking toward greater economy and even higher quality. The next two or three years will undoubtedly show whether the American manufacturer of tool steels can afford to operate an induction furnace, or whether he really can afford to operate without an induction furnace.

*Electrical Equipment and Motor Generator Set Has Been Perfected and Is Quite Rugged, Requiring Only Normal Care, Attention and Maintenance Expenditure.*

# Pickling . .

## a modern cleaning method

by J. C. Weaver

THERE STILL SEEMS to be a suspicion in the minds of many fabricators of various types of metal products that pickling is still an expensive, sloppy and unhealthy operation. Practically every metal part, before it reaches the ultimate consumer, has been descaled at least once and generally more often. Inasmuch as this operation is so important and occurs so often it will be well to consider the most economical and practical method of accomplishing the required results.

There may be several types of scale to be removed, but it is not in the chemistry of these that we are interested just now. Before the steel sheets, forgings, or stampings can be further processed, it is necessary to remove this scale, whatever its nature, and it is the purpose of this article to point out the various advantages of pickling, as a process of cleaning, and to compare it with other commercial methods of de-scaling.

Confining attention to the problems of removing various oxides from metal, we find there are three principal methods now widely used, namely, sand blasting, tumbling and pickling. Let us review each of these processes in a few words.

Tumbling is an operation that is widely used in the foundry. There, its principal purpose is to knock the remaining traces of molding sand clear of the newly made casting, and to loosen the remains of the core sand. It can be applied to comparatively few pieces of metal in fabrication other than castings and is, therefore, not of sufficient importance to discuss at this time. This leaves us with a choice of sand blasting or pickling.

Sand blasting generally does a satisfactory job of removing the scale. It is not an ideal method because the equipment is expensive to buy and maintain and the cost of the operation is high. Sometimes, also, sand blasting polishes the scale into a clean-looking, smooth surface that may not be discovered for its real character until the pieces are machined.

For instance, consider forgings, which are subject to small cracks, or crevices or laps. The sand blasting operation has a tendency to peen over and cover small surface defects and these faulty pieces may often be shipped unwittingly to the customers.

The term pickling is applied to the use of acid solutions in which the pieces are to be immersed.

Pickling, as a process, has been used ever since wire drawing and sheet rolling have been practised. The derivation of the term possibly refers to the preservation of fish or vegetables in brine or vinegar — any sour solution was known as a "pickle". The acid mostly used for this purpose is sulphuric, but hydrochloric is favored for some products. Pickling, as it has been done in years gone by, and is still being done in some places where they should know better, is also far from ideal in all respects. On the other hand, pickling in its modern applications lends itself readily to efficient production requirements. The cost of equipment is comparatively low, the cost of operation is also reasonably low, and the action is efficient and sure.

A properly pickled bar, rod, piece of steel sheet or a forging will be clean and smooth and any surface defect will be readily exposed; all the oxide has been removed chemically from the metal underneath.

## Early Practices

It might be well at this time to recall the early methods of pickling. In this way, the developments that have been made in this practice will be prominently in evidence — as a matter of fact, the present pickling practice has been evolved from the old-time methods. Inasmuch as very great progress has taken place in the pickling operation as applied to heat treated parts and forgings, the discussion will be confined to phases adaptable to this particular type of work.

Years ago a barrel of dilute sulphuric acid was kept near the annealing furnaces and the pieces were dipped in this acid and then piled into the furnace where they were kept until they became a cherry red. Then there appeared on the surface of the steel a reddish soot which, when the furnace door was opened and

*Not so Long Ago, Pickling Required Much Labor in a Sloppy, Fume-Laden Room. Chemical studies have controlled the acid consumption and suppressed excessive fumes; mechanical engineering has supplied the necessary labor-saving devices; and metallurgical advance has delivered acid resisting metals for tanks, baskets and grappling irons.*

the contents removed, would rush out and cover everything in the room.

This, of course, was a crude, expensive and messy operation.

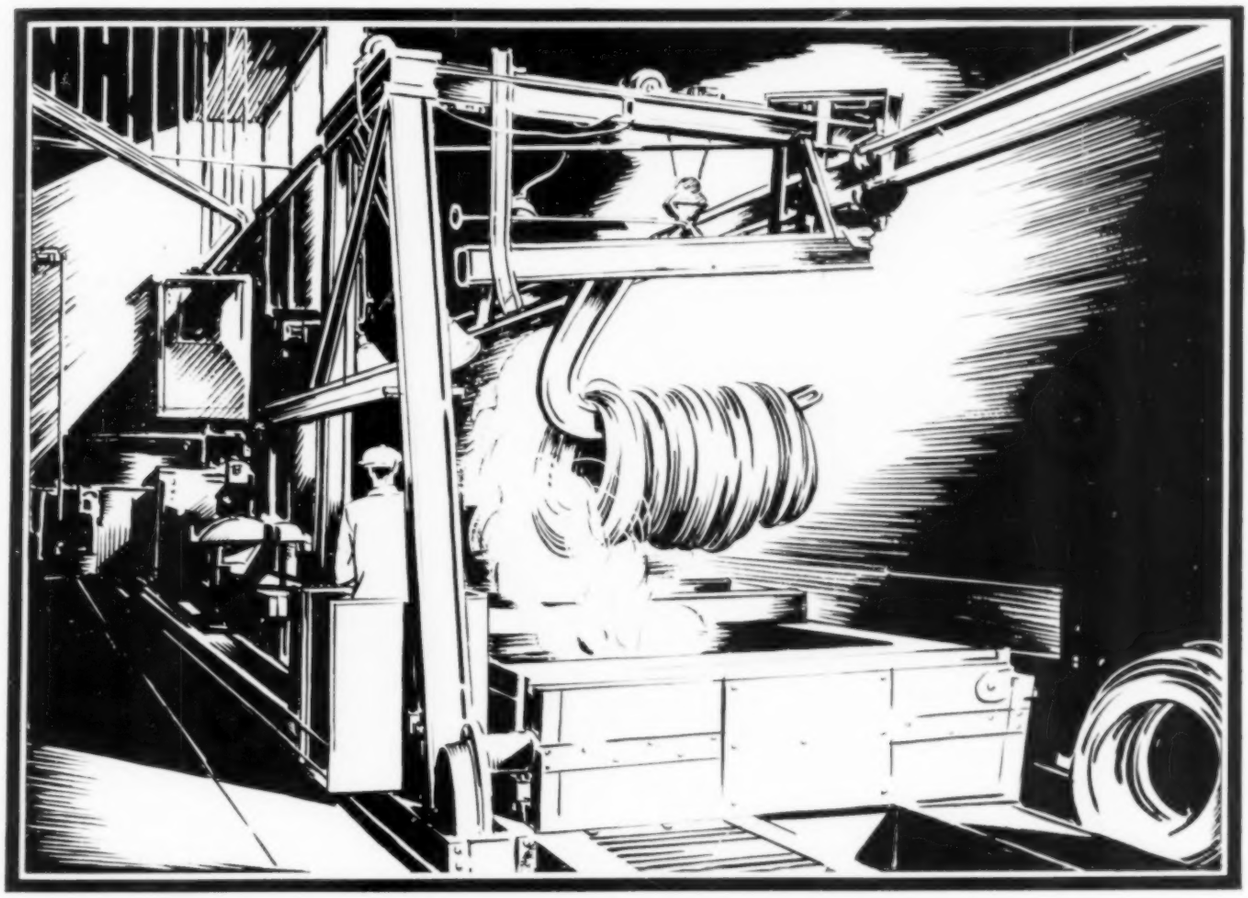
Another practice was to pile the ware on a fork, sprinkle the acid over it by means of a broom or similar methods, and then place in the furnace. This produced approximately the same results as the previous method except that the loose oxide was heavier and had a tendency to stay on the floor rather than go into the air as a dust.

A still more cumbersome and costly operation was to place the various pieces to be descaled into a heavy barrel and, before sealing the top, sprinkle powdered sulphur over the pieces. This barrel was then placed in the fire for several hours, taken out and cooled. The cold pieces were then removed from the barrel. This operation did a fair job as far as removing the scale was concerned, but had a tendency to soften the metal, which was not always permissible.

Patented solutions and methods almost without number have been proposed — as is always the case when any art is strictly rule-of-thumb — but little progress was made until intensive chemical studies were made by technologists who had turned their attention to this branch of the steel industry.

The immediate fore-runner to modern pickling was the use of acid tanks over which was placed some sort of hand winch. The load was raised and lowered into the bath after it had been tied together with chain or wire. The fumes from this operation were carried off by means of a wooden stack placed at the back edge of the tank and connected to a chimney to make the best possible natural draft. This method, of course, was a big improvement over any previous practice but recent developments have shown that it was far from perfect.

The next improvement is shown in the artist's sketch — the use of wooden baskets for the ware. This considerably increased production, but the operation was expensive, largely



because of the construction and material used in these wooden baskets or crates. Even those made with the greatest care went to pieces quickly in the acid solutions. However, this type of equipment represented best practice for a long time. The only real improvement in this

*Any Product of Hot Working, Such as a Bar, Strip, Sheet, Forging, Rod, Must Have the Scale Removed if the Surface Is to Be Inspected for Defects or Finished by Cold Work.*

general apparatus for conducting the operation is due to the recent discovery of acid resisting metals which could replace the wooden baskets and give a longer life and greater production.

With such crude apparatus, picklers were able to remove the scale but they had no control over the temperature of the bath, the acid concentration or the consumption of steam for heating purposes. Either there were no scientific checks available, or those that could be applied to the process were neglected. Therefore, the operation continued to be expensive, sloppy, and created unpleasant working conditions. Such pickling certainly had no permanent place in scientific shop practice, and were it not for the more modern methods, it would be safe to say that almost any other cleaning practice would be preferable from the standpoint of health and cost.

We have pictured old-fashioned methods with the hand winch and rough wooden baskets. Today acid resisting metal baskets can be fabricated from rolled stock so that a comparatively small amount of the space in the pickling tank is consumed by the carriers or racks used for the parts in process. Although the original cost of these metal baskets is much higher than the first cost of those made of wood, the life is so much longer that it is an economical move to install acid resisting baskets. These new metallic alloys can also be used for the tie rods and binders for the tank, thereby giving them an indefinitely greater life.

Today we also have efficient types of hoists for carrying the ware in and out of tanks. For larger production, we have the continuous picklers which cut down the man power and increase the production.

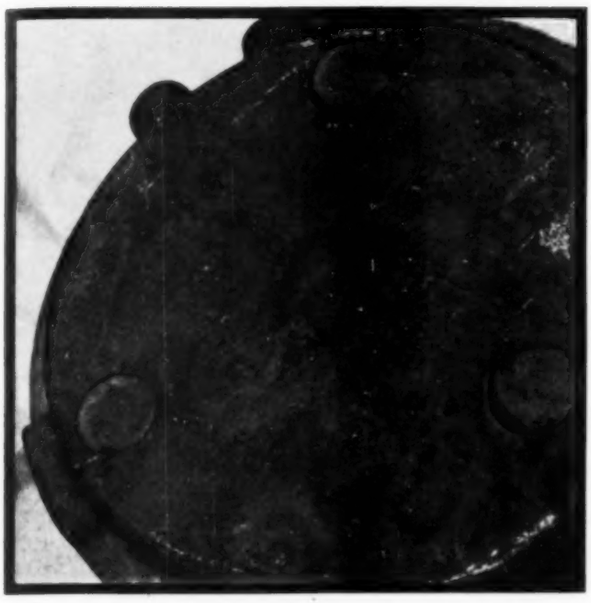
By these means we have eliminated most of the objections from the standpoint of equipment. Now let us consider the actual chemical reactions and the cost.

## Chemical Control

Within the old-fashioned equipment there was no control over the chemical reactions and a considerable percentage of the metal being cleaned was lost due to "over pickling", an operation which eats away too much of the base metal. There was also the danger that the metal would absorb hydrogen gas, generated from the decomposition of the acid. These two chemical phenomena caused great annoyance and loss to manufacturers but within the last few years, there have been mechanical and chemical controls developed that practically eliminate these two dangers, so that we can now be sure of no excessive loss in metal nor hydrogen absorbed. These matters I hope to discuss in considerable detail in later articles contributed to METAL PROGRESS.

The greatest costs now remaining to consider are for acid, the steam, and labor. There are now available, efficient and economical methods of testing a pickling solution, and it is a very simple matter to find out exactly when a tank should be dumped and when acid should be added to a solution.

We also have a simple way of controlling the steam flow into the pickling tank in order that the temperatures may be held constant and



*Pickling Removes the Scale Completely and Lays Bare the Undisturbed Metal Surface Underneath.*

the minimum amount of steam used. There are also available "fume eliminators" which prevent the liberation of excess acid fumes. Their use, together with improved ventilation, has not only made the cleaning room a livable place, but at the same time has saved acid that would otherwise be carried into the air and wasted. Uncontrolled acid fumes play havoc with the structural parts of the building, even if the workmen's lungs can stand it.

There is not space in this introductory chapter to go into the details of the chemical reaction of various acids on the different kinds of oxides, but in a general way, it may be said there are three different oxides that form on iron and steel. First we have hydrated ferric oxide ($Fe_2O_3 + H_2O$); this is ordinary brown rust and is soluble in dilute sulphuric acid. Second, anhydrous ferric oxide ($Fe_2O_3$); this is the same iron oxide as the brown rust mentioned above, but is formed in the absence of water. It is the well-known blue scale and is somewhat soluble in pickling acids. Third, magnetic oxide ($Fe_3O_4$); this is the black scale formed in hot working operations and is only slightly soluble in acids.

Two acids are available for commercial pickling. The first is sulphuric, an acid with comparatively little action on the actual scale itself. It seeps in behind the scale, touching the base metal and forming iron sulphate and hydrogen gas. The latter collects in a bubble and blows or "explodes" the scale from the part being pickled. This acid is much cheaper than muriatic (commercial hydrochloric acid), is satisfactory in results, and is generally used.

Hot muriatic acid, instead of working on the base metal, dissolves the oxides themselves. This operation is slow and more costly in time and acid consumption. Likewise the fumes from the hot solutions are more troublesome.

From this brief statement of essentials it might seem that sulphuric acid is dangerous to use because it works on the base metal and might have a tendency to cause hydrogen absorption. This assumption disregards the fact that hydrogen absorption may be controlled by some one of the various types of inhibitors now on the market, which stop the acid action as soon as scale has been removed.

Photographs on these pages, at about half size, show the surfaces of a typical forging before having the scale removed and after sand blasting or pickling. These clearly indicate the importance of many points briefly mentioned in the foregoing remarks, and also indicate how necessary it is (for quality work) to get clear down to bare, undisturbed metal in order to be sure that surface inspection will discover all the defectives.

*Sand Blasting, While it Gives a Clean Metal Surface, Is Liable to Burnish or Peen Over Small Defects.*

# Tantalum

## the long-elusive metal

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Staff Article

EXASPERATED scientist Ander Ekeberg, professor of chemistry of Upsala University, Sweden, in 1802 discovered but could not isolate a new metal in a bit of ore he was studying. He knew a new metal was there, but after hundreds of attempts he gave up trying to separate the element from its compounds. He named it, however; named it tantalum because it had tantalized him by keeping just out of his reach.

For nearly a century scientists all over the world tried to isolate tantalum. Once in a while some unusually successful man would succeed in producing a black metallic powder or a bit of hard and brittle metal, but not until 1903 did Von Bolton of Germany produce a ductile form of tantalum which could be drawn into fine wire. Under his process, a quantity of ductile tantalum was produced in Germany and used there and in this country for filaments in incandescent lamps.

Use of tantalum tapered off when tungsten became the most popular metal for lamp filaments. The War probably put a stop to the German manufacture, and little or no metal was made between 1911 and 1922. Then, after a long research, Dr. Clarence W. Balke of the Fansteel Products Co., North Chicago, Ill., obtained a bar of almost chemically pure tantalum, which was passed through a rolling mill repeatedly and was rolled down to a thin sheet without cracks and without defects. His great accomplishment was to put tantalum on a *real* commercial scale — in large pieces — in ductile form — in commercial quantities.

The unpolished metal had a steel blue color, but when highly polished was white, almost like platinum. It was tough, malleable and very ductile. It was easily cold worked by hammering, rolling, drawing, punching, sawing, or machining.

Tantalum is both a rare and a noble metal — rare because its ore is obtainable only in limited quantities, and noble because, like gold and platinum, it does not enter readily into compounds with other chemicals. Although rare, it is only one-fourth as expensive as gold and only about one-twelfth as expensive as platinum. Consequently, tantalum is one of the few rare and noble metals which has found many applications in industry.

In the Pilbarra district of western Australia, 450 miles from the nearest railroad, are the only mines which yield the ore in workable quantities. From this hot and desolate country, modern engineering has brought the ore tantalite from beneath the surface and prepared it for export to central United States, thousands of miles away.

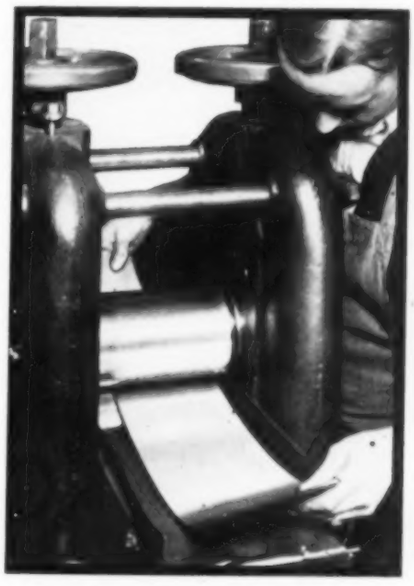
Tantalum is found in association with the metal columbium — the ore tantalite is what the chemist knows as a "columbate and tantalate of yttrium, iron, uranium and cerium earths." Often tantalite contains as much as 80% of the valuable tantalum oxide. Manganese, titanium, tin, tungsten, are almost invariably present in the ore. The winning of tantalum from such a complex ore comes after a series of chemical and metallurgical processes at the Fansteel plant, with the product a 99.9% pure metal.

The first step in refining tantalite is to grind the ore to a fine powder and then fuse it with caustic soda. This puts most of the iron and other metals into such condition that they can be leached out with hydrochloric acid; the residue is a white mixture of columbium and tantalum oxides. Hydrofluoric acid is used to separate these two; complex soluble salts are formed but the one containing tantalum crystallizes out before the other. Treatment with ammonia then forms tantalic acid which is ignited to oxide. Mixed with suitable reducing agent in an electric furnace capable of approaching a temperature of 5,000° F., pure metal is finally secured.

Many years of tests, both in the laboratory and in service, have defined tantalum's properties and limitations. The metal is unaffected by practically all forms of corrosion. Aqua regia, which dissolves platinum and gold, does not affect tantalum nor do hydrochloric nor nitric acids. Hydrofluoric acid, which dissolves even glass, seems to be about the only acid which tantalum cannot resist. Such unusual chemical properties have been responsible for one of its most important commercial applications — namely, the manufacture of crucibles, evaporating dishes, electrolytic cathodes, and other chemical and analytical equipment where platinum, twelve times as expensive, has been formerly used.

Commercial tantalum is just about as hard as cold rolled steel. This combination of corrosion resistance and hardness at once suggested the application of the metal for tank and pipe linings and tubing for use where a strong, noble metal is necessary. The refining of pharmaceutical phenol is a branch of the chemical industry which has peculiar requirements for the lining of stills and containers; usually silver is the metal, but tantalum, costing only little more, lasts indefinitely longer.

The rayon industry, large and ever growing, finds tantalum valuable for spinnerets, which are the man-made counterparts of the spider's spinning apparatus. These devices are small thimbles drawn from sheet tantalum, with a number of tiny but accurate holes drilled in the crown. Through these openings streams of liquid



cellulose are forced, which harden immediately into fibers when they react with the acid on the other side of the spinneret. The structure of the fiber is determined by the size and shape of the holes, and only a hard, corrosion-proof metal will prove satisfactory for this use. Spinnerets of platinum and gold were formerly used generally, but the cheaper and more durable tantalum is rapidly coming into wide use.

From the standpoint of fabrication, it has been found that tantalum is extremely ductile under cold work, and, when annealed, will withstand a surprising amount of working. It can, moreover, be easily welded to itself and to other metals by the roller or electric spot welding methods and by a modification of the arc welding process. It can be surface hardened by heating in air for a brief time. It is impossible to hot work the metal, however.

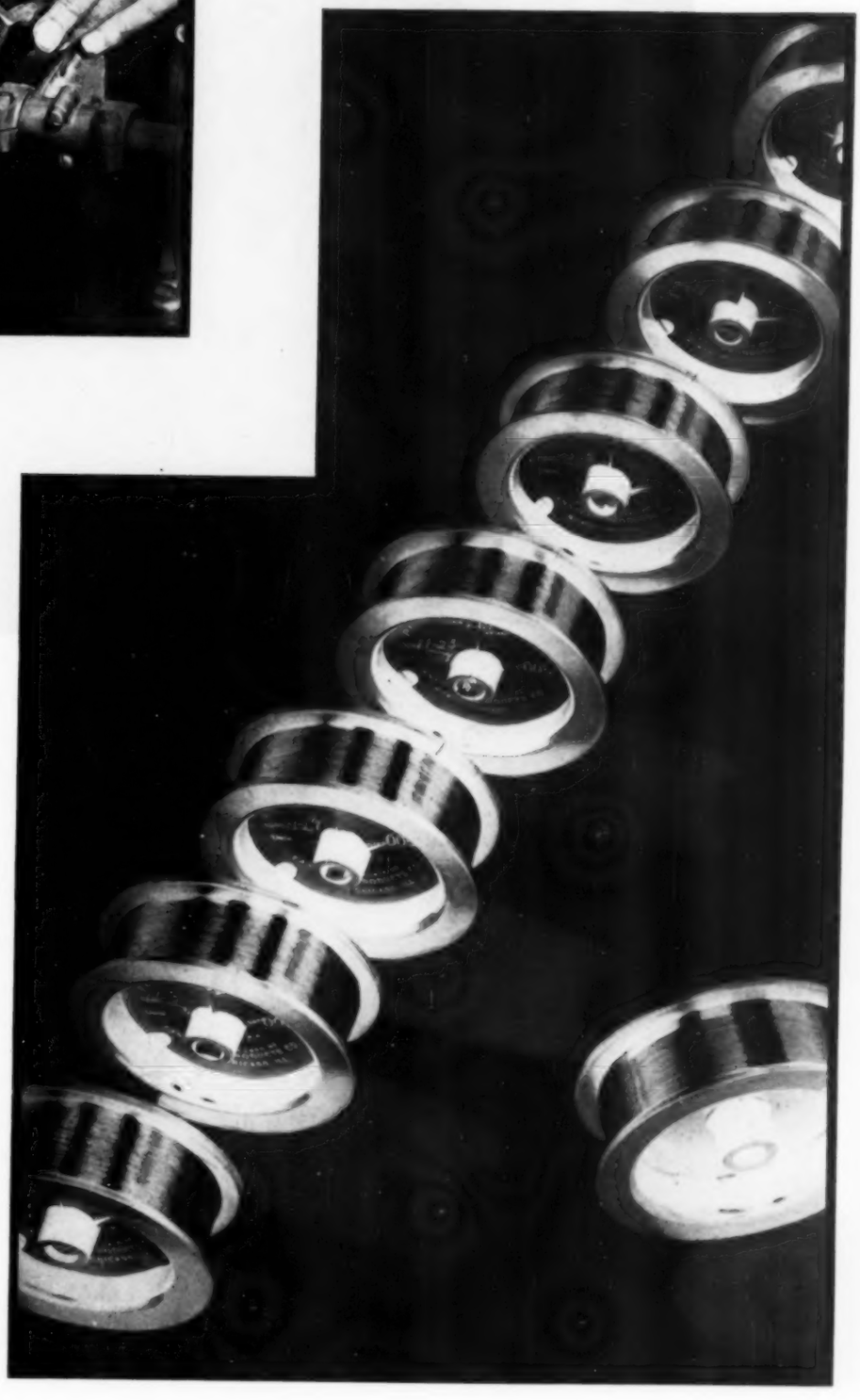
Tantalum's ability to absorb common gases such as hydrogen, oxygen and nitrogen at moderately high temperatures has made it essential in power vacuum tubes. In building these tubes, a bit of tantalum is welded to some other part of the tube in order that it may help to retain a high vacuum by absorbing both the gases which are present in commercially evacuated tubes, and also those which may be given off by the other metals in the bulb. Tantalum is also used for plates and grids, and successful 100% tantalum tubes are made and used by the radio industry.

In gas filled tubes of any character, tantalum may be used to advantage, as in the glowing tubes of neon signs. A special tantalum base alloy used as an electrode helps to preserve the original pressure of the gas in such tubes. In other applications, this rare metal absorbs gas impurities and retains them; in certain other types of vacuum tubes it introduces very small and measured amounts of pure gases.

To do this, a piece of tantalum is heated to a correct temperature, about dull red, in the presence of the pure gas which is then absorbed in the metal until an equilibrium is reached. This gas will remain in the tantalum until it is driven out at a higher temperature, and when the tantalum is so placed in the tube that it may be heated, the gas can be absorbed or liberated according to desire.

Another very important use of tantalum is in rectifiers, particularly for use in railroad signal operation. The metal here acts as an electrolytic valve, passing current in only one direction, thus automatically acting as a charger where an alternating current is used. Its resistance to corrosion is another reason for tantalum's wide use in rectifiers.

This tantalum rectifier has gradually become the standard equipment for charging railway signal batteries, not only in America, but in such far-off spots as India, New Zealand and Japan. It has also been adapted to charging telephone switchboard and PBX batteries, and is being rapidly installed in such places.



*Tantalum, When 99.99% Pure, May Be Rolled Into Thin Sheets and Drawn Into Fine Wire. Its ability to absorb definite amounts of gases at definite temperatures is utilized in radio construction; by inserting correct amounts of pretreated wire the gaseous content of the tube is under definite control*

# how to select thin plate . . . For Deep Drawing

by H. T. Morton

*Photos by L. A. Rummler*

VARIOUS PARTS such as automobile bodies, fenders, wheels, brake-drums, roller bearing cups, bearing retainers, toys and air cleaners, are cold formed from flat sheets or strips. Very often the steel cracks or roughens during this operation, and many of these cracked or roughened parts are damaged beyond repair and are scrapped, a total loss to the manufacturer.

This damage represents an enormous annual loss. It may be caused by one or more of the following factors: Quality of steel, die design and machine set-up. If the best quality of raw material can be obtained, one variable is eliminated and the mechanical engineer, toolmaker and mechanic can then proceed to overcome their difficulties.

Before a metallurgist can recognize a good deep drawing steel for a given part, he must have a method of testing that steel. Various men have investigated thin material like automobile sheet, but heavy-gage steel has been quite neglected. In this paper I will describe a method of testing steel 0.250 to 0.300 in. thick, and show the relationship of these laboratory results with records obtained simultaneously in production. Such data should be of value in various plants confronted with the problem of testing heavy gage deep drawing steel for other operations besides the manufacture of ball bearings.

Before proceeding, it would be well to note some of W. H. Graves' remarks about thin steel for automobile bodies and fenders. In a lecture on "Sheet Steels for Automobiles" given before the American Society for Testing Materials held in Detroit during the spring, he said: "The work on the testing and specification writing for sheet steel described herein was based on the hypothesis which later proved to be fact that the art of testing metals had reached a further state of development than had the art of die design, die set-up and press operation. In other words, it is our belief that metallurgists should be able to tell more accurately in the laboratory that a piece of steel will or will not work on a particular piece than could a press-room operator who has many other problems to contend with. . . . . It is quite possible to divide sheet steel for drawn parts into two classifications only: 'Extra deep drawing' and

*Finished Bearing Cup Shown at Left. Defective caused by split rim, shown right, is caused by solid non-metallic inclusions*

'deep drawing.' The values given below are suggested for No. 18 and No. 19-gage steel.

"It is possible to make parts with steel having Erichsen values as low as 8.5 or 9.0 but they must have extremely low draws. The hardness limits have been discussed and are given here as the ideal for a specification."

| | Extra Deep Drawing | Deep Drawing |
|---|---|---|
| Analysis | S.A.E. 1010 | S.A.E. 1010 |
| Erichsen value | 11.0 minimum | 10.5 minimum |
| Rockwell hardness | B-43 to B-53 | B-43 to B-53 |
| Grain structure | As per standard sample or grain size count | Not specified |

Mr. Graves' classification, "extra deep drawn parts," refers to such articles as headlights, body panels and fenders where sometimes more than one set of dies are required to obtain the proper depth. "Deep drawn parts" do not require as severe cold working, and the roller bearing cups discussed in this article fall into the latter classification.

They were tapered roller bearing cups as used for front wheel bearings of automobiles and in other places. The material was received in flat strips 0.250 to 0.300 in. thick from which the blanks were stamped and then formed into the shape shown in the figures above. The bottoms of the cups were knocked out and the rim of the cup was subsequently machined, carburized, heat treated, ground and inspected ready for assembly into the finished roller bearing. (An idea of the finished article is given on page 58.)

Shortly after the first shipments of steel were received and the breakage of formed parts was noticed, the analysis was changed from S.A.E. 1020 to the following: Carbon, 0.08 to 0.13%; manganese, 0.30 to 0.60%; phosphorus, under 0.040%; and sulphur, under 0.040%.

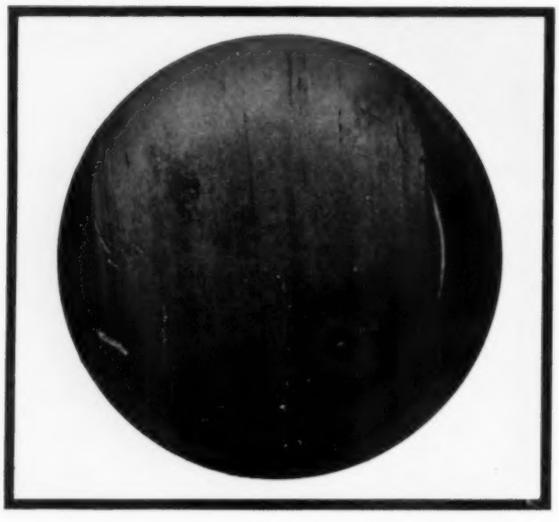
All of the steel was made in open-hearth furnaces under careful control to eliminate slag and other inclusions and to obtain a carburizing quality. Ingots were broken down into billets, which were carefully inspected to eliminate seams, decarburization, and other surface defects. The billets were rolled to size on the hot mill, annealed, pickled, and oiled ready for shipment. All of the annealing was done in 10-ton and larger furnaces of the car-bottom type.

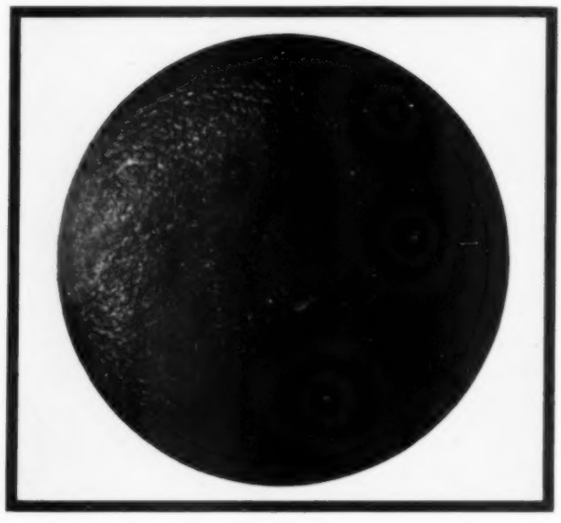
Grain size was controlled to give medium size — not less than 6 nor more than 35 grains per sq.in., counted at 100 magnifications after carburizing 8 hr. at 1700° F. This grain size was adopted to give proper fracture after heat treatment and was not studied as to its relation to deep drawing quality.

The troubles encountered in forming these roller bearing cups could be divided into three groups:

1. Breaking of the edge of the cup.
2. Splitting of the cup on the back of the bend.
3. Difficulty in machining.

It was our aim to devise a standard method of testing shipments of steel as received. Then each shipment which passed the test requirements could be unloaded into stock, ready for use when required. Defective material could be returned to the mill without unloading. When such an ideal has been approached, there should be no loss thereafter in the press department due to defective steel, and any high percentage of breakage could be overcome by adjusting the dies and presses. During the investigation each shipment received a number, which was marked on a card accompanying each pan of parts through production. The foreman sent accurate records of breakage to the laboratory. These records were kept, correlated and compared at frequent intervals.





*Small Seams Cause Cracks if They Are Located at the Sharpest Bend. Roughening shown on the right is due to decarburized surface*

The simple solution for the breakage of cups at the open edge as shown on page 55 would be to find a relationship between the location of the break and the direction of rolling of the original strips. Accordingly, several hundred cups were examined but unfortunately showed no such relationship. This meant that the internal and physical properties of the steel were responsible, rather than the fiber or flow lines induced by rolling.

As stated previously, W. H. Graves used the Erichsen testing machine for thin strips. In 1925, when this work was begun, no machine had been recognized or used for determining ductility of heavy-gage material. There was available a universal testing machine as well as the Rockwell and Brinell hardness testing machines and the microscope. The following data were recorded from tests on each shipment, when received: Elastic limit, tensile strength, elongation, reduction of area, Brinell hardness, microstructure, and amount of inclusions.

Photomicrographs were made of the inclusions on all early shipments of steel. A longitudinal section of steel from a defective shipment is shown at the left of the group on the bottom of the next page, taken at 100 magnifications after careful polishing but without etching. The inclusions are readily noticeable, and this photomicrograph is typical of those taken of several of the early shipments which were badly defective.

A photomicrograph alongside shows the inclusions in shipments which worked satisfactorily in the presses. There was little difference in the physical properties, and this indicated that dirt and slag inclusions have a direct relationship to the percentage of broken cups.

Accordingly, the cleaner steel shown was adopted as a standard containing the maximum amount of inclusions allowable on all shipments received thereafter.

All specimens for cleanliness were longitudinal sections, very carefully polished so as to eliminate all polishing pits but to show slag or other inclusions, and photographed at 100 magnifications.

Tensile tests were compared with produc-

tion results of the earlier shipments, but a sufficient variation in the elastic limit or reduction of area was not found to account for the difference in the percentage of broken cups. Careful study of these early results (largely done by H. G. Freeland) showed that, despite some apparent contradictions, any steel which had a low tensile strength combined with low elongation gave relatively poor performance in the dies. Consequently, attention was focused on these two physical properties, although in the routine of tension testing the elastic limit (drop of beam) and the reduction of area continued to be noted.

Tension tests were made on flats milled from the original stock. Original surface of the stock as received was undisturbed. The coupon in the grips was 2 in. wide; the necked portion had 5 in. of parallel sides, milled to 1½ in. with a tolerance of 0.005 in., and ending in fillets of 1½-in. radius. Gage length for elongation was 4 in.

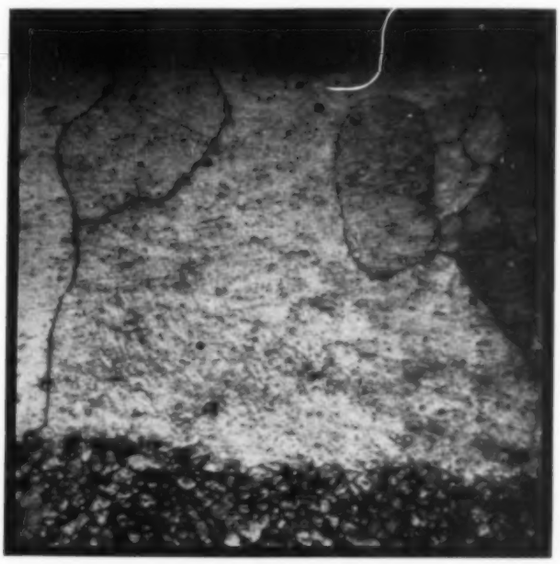
Tests run to determine the effect of testing machine speed did not show sufficient differences to consider this factor. Since specimens did not have the standard 8-in. gage length recommended by the A.S.T.M., the steel companies used the same sized specimens so that results would be comparable. (Let me record our indebtedness to Pittsburgh Crucible Steel Co. and Donner Steel Co. who cooperated fully in our efforts to secure steel of correct deep drawing qualities.)

Tabulation of the tensile strength, per cent elongation in 4 in., and amount of breakage in production was continued. A set of representative values is shown on the chart on page 59.

Here it was found that breakage did not increase when tensile strength values dropped, *provided* the elongation value increased; or, inversely, when the elongation dropped and the tensile strength increased. The latter results were shown more clearly in tests on a nickel-molybdenum carburizing steel, S.A.E. 4610. These had, respectively, average tensile strength of 66,000 lb. per sq.in. with elongation of 32% and 70,000 lb. per sq.in. with elongation of 28%, yet all cups produced were perfect. Examination of the points plotted in the figure indicates that nearly all of the plus marks and cross marks, representing "no breakage" and "under 0.3% breakage" fell above a line connecting 17,500 lb. per sq.in. and 41% elongation with 56,000 lb. per sq.in. and 36.5% elongation. Most of the bad shipments fell below this line.

The noticeable exception of 823, a steel giving 7.7% cracked cups, was due to decarburization of the surface (as explained later) and of 874, 936 and 941 were due to surface seams which caused a large number of the cups to

*Steel of Correct Tensile Properties, Yet Having Many Slag Inclusions, Will Not Stand a Deep Draw. Clean steel shown at 100 diameters in center is the standard which must be met. Decarburized surface, caused by improper annealing, is responsible for roughened surfaces on drawn cups*



crack in the direction of rolling of the strips. Thus it appears that deep drawing properties are a function of the relation between tensile strength and per cent elongation, both of which should fall above the graph.

Brinell hardness values did not vary sufficiently to show any relationship to the deep drawing quality, although it has a definite relationship to the tensile strength. It is of importance to the press operator because "it is possible," in Mr. Graves' words, "to equip a plant to work uniformly hard steel regardless of whether the hardness is high or low, with the one exception of spring-back in the die. On the other hand, it is impractical to teach press men to handle a mixture of steels, as to vary from a hard to a soft steel, or a strong to a weak steel. Experience has shown that, without exception, the Rockwell hardness of the steel will be a definite indication of the spring-back to be expected. The harder the steel, the more the spring-back. The limits to set, of course, depend upon die design." As Rockwell readings can be converted to Brinell numbers, the value of a uniform hardness becomes important.

### Splitting of Cups

Examination of several hundred split cups showed that all of them split at the curve on the outer surface, longitudinally with the direction of rolling. A badly split cup is shown in the left hand figure on page 56. Numerous split cups were etched and showed surface seams; our illustration shows prominent seams on the surface of the steel at many other places than at the point of rupture of the metal. When a seam comes exactly along the line of bending, due to its weakening effect, it will cause splitting. However, other split cups did not have prominent surface seams; pickling the surface would generally show the defect with more or less clarity.

To prove whether this failure was caused by surface seams or by internal defects, 100 blanks free from seams were selected and the same quantity of seamy blanks assorted. These were run through the press in groups of ten good followed by ten bad, and the cups reassorted as before. Twenty-five per cent of the seamy cups split, while none of the smooth surfaced blanks split. One can interpret these results in no other way than that surface seaminess should not be permitted in deep drawing steels.

Further work showed that seemingly minute seams would cause splitting provided that they were in the right position on the blank when formed. These seams could be caused from rolling, from insufficient chipping of billets, or from scratching in the finishing mills. This means that deep drawing steel billets must be carefully inspected so that previous seams are removed and care must be taken to finish the steel in such manner as to leave the steel free from seams or other surface defects.

Another type of splitting occurred on occasional shipments.

These defective cups split with a very irregular edge and had a very rough surface resembling that of an orange peel. A rough cup is shown at the right on page 56. Investigation showed that this was caused by decarburization. The surface metal was recrystallized into large weak grains; microstructure of a longitudinal section is reproduced at the right on page 57. You will see a large quantity of ferrite along the edge of the strip with thin boundaries of pearlite extending at right angles to the edge.

To make quite sure that this was not "recrystallization after annealing cold worked steel" the surface metal was carefully filed off and analyzed. The result showed 0.05% carbon, while the center of the strip analyzed 0.12%

carbon. The depth of decarburization varied from zero to 0.025 in.

When machining the decarburized cups just described, irregular results were noted which the men said were caused by "hard and soft spots." Actually, no differences in hardness could be detected with the Brinell and Rockwell instruments available. However, during several days' run on the rough cups it was found that the tools required sharpening more often. In one test, a tool which had been running well on regular steel chipped out when turning the second decarburized cup. This further showed that deep drawing steel must be properly annealed and free from decarburized areas on its surface.

### Proper Method of Finishing and Annealing

The proper method of finishing this deep drawing steel was studied on one heat of steel. A single heat was studied, in order to eliminate any variations due to analysis, inclusions or grain size.

Two piles were finished and annealed in the regular manner. Another was finished at a high temperature on the hot mill and annealed. Two piles were finished at lower temperatures than usual and annealed. The last pile was annealed twice.

Two of the piles had numerous split cups due to surface seams; otherwise only a few cups in a pile finished and annealed in the regular manner broke. This indicated that either a high or a low finishing temperature on the hot mill will give satisfactory results after annealing.

One part of a nickel-molybdenum steel heat (S.A.E. 4610) was annealed above the critical while another was annealed below the critical. Both lots formed without breakage, indicating that either type of anneal would be satisfactory for deep drawing steel.

Summarizing the results, we have found that thin plate suitable for deep drawing must have a minimum of slag, other inclusions and internal defects. The most that can be endured is shown in the center micro on page 57.

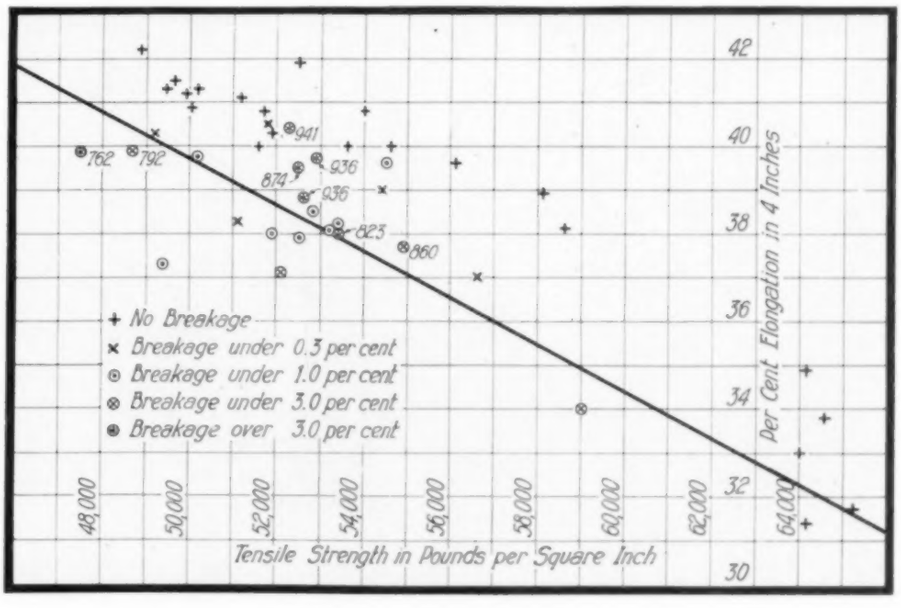
Tensile strength and per cent elongation have a definite relationship to deep drawing quality, as shown in the graph below.

The surface of the strips must be free from seams, rolling laps, scratches and decarburization.

The steel must be annealed.

These rules apply to alloy carburizing steels as well as to plain carbon carburizing steel, except that the former have higher tensile strengths and hardness with lower percentages of elongation.

No relationship was found between elastic limit or per cent reduction of area and deep drawing quality.




*A Clean Steel, Free From Surface Seaminess, Whose Tensile Strength and Elongation in 4 Inches Plots Above This Inclined Line, Will Be Suitable for Deep Drawing*

# a Model Heat Treat . . . for precision grinder plant

IN ORDER TO INSURE a closer watch on the parts going into the construction of surface and internal grinders, built for production yet to work within limits on the order of 0.0002 in., the Heald Machine Co., Worcester, Mass., has, within the last year, enlarged and remodeled its heat treating department. The entire equipment is contained in a separate building 30 ft. wide by 80 ft. long, with high trussed roof, well ventilated, and with walls almost entirely of glass. The general air of light and cleanliness gives the impression more of a research laboratory than of a production department.

Across one end is a low partition setting off space for the chemical and metallurgical laboratory and the metallurgist's office. Routine chemical analyses are made of every lot of steel as it is received. Microscopic examination for cleanliness and homogeneity of structure is also the rule. For the latter a binocular microscope, using lens combinations for 100 magnifications, has been found to be very suitable.

Balances, hoods, combustion trains, and other chemical equipment are installed sufficient for all routine work on steels, coals, and lubricating oils, and retained in a permanent set-up ready for instant service.

The old oil fired muffle furnaces in the old heat treating department, run by the human eye pyrometer, have been entirely replaced. Most of the new furnaces are electric, controlled by Leeds & Northrup recording potentiometers and time clocks. Salt baths and high speed furnaces, since they are seldom operated simultaneously, have burner controls or contactor panels connected through proper switches to a single control. An indicating pyrometer with large scale for easy reading at a distance is a part of this set. The equipment is mounted in a row on the partition mentioned above, but facing the heat treatment department, so the operators can readily consult the temperature charts at any time. Switches and contactor panels controlling current into the furnace resistors are encased in steel cabinets against the wall immediately to the rear of each furnace.

With all potentiometer equipment together at one end of the room, the high heat furnaces are backed up alongside one wall. Annealing furnaces face them from the opposite side and

the far end is taken up by a blacksmith's forge, anvil, bench and small drop hammer. (The latter equipment is properly hooded, and is used for miscellaneous plant maintenance only.)

Two large electric furnaces, operating with gas curtains, do most of the annealing, carburizing and hardening of the machine parts in regular production. Some spindles are 56 in. long, so the bigger furnace of the two (an American Electric Furnace) has a hearth of 60x36 in. It is listed as a 70-kw. furnace. Alongside it is a General Electric 28-kw. furnace with heating chamber 18 in. wide by 36 in. long and 18 in. high. A small furnace of the same make is used for hardening small fixtures and parts, and a gas fired two-hearth furnace is available for hardening parts of high speed steel.

Case hardening is done in an electrically heated pot 9½ in. diameter by 16 in. deep. The medium used is "aerocase," which has been found to give satisfactory metallurgical results, and is superior to cyanide in the heat treating department, since the fume nuisance and poison hazard are eliminated.

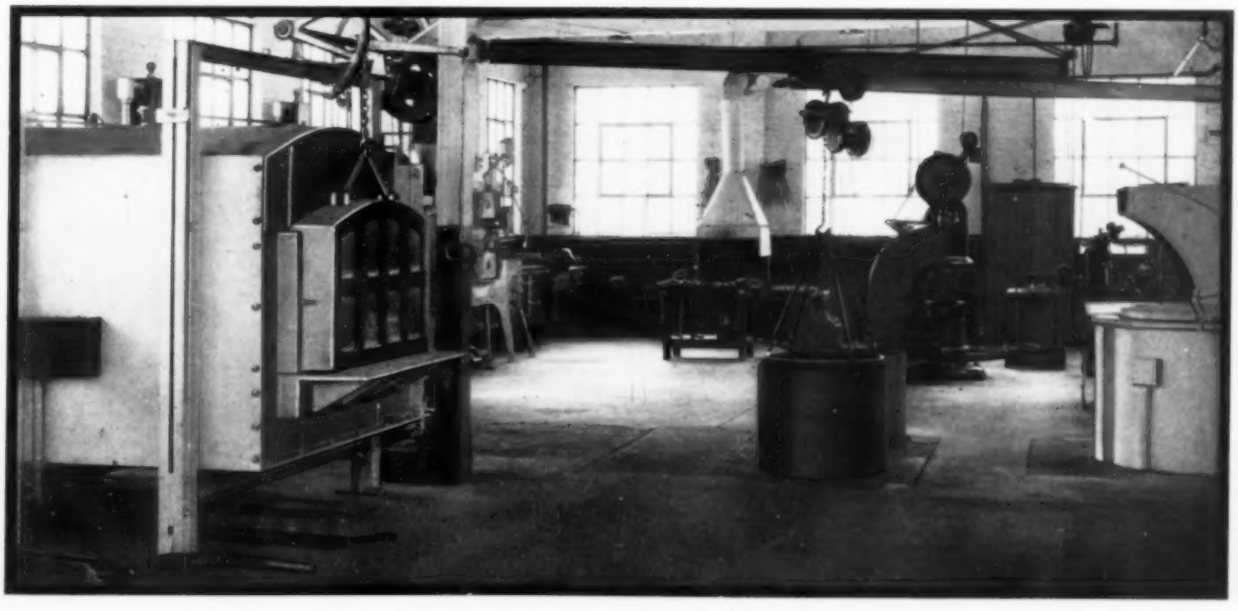
Salt tempering baths across the aisle from the high heat furnaces include a hooded rectangular pot, 48 in. long, 24 in. wide, and 15 in. deep in a gas fired setting manufactured by Strong, Carlisle & Hammond. An electrically heated homo furnace (22 in. diameter by 25 in. deep) is also found quite useful.

In the center of the aisle, handy to the entire group of furnaces, are two quench tanks, 30 in. diameter by 5 ft. deep, set 4 ft. into the ground. One has circulating oil, and the other circulating water. The entire working area is adequately covered by jib crane for heavy loads.

Material to be carburized is packed in cast iron pots in a small shed some distance away, trucked to the heat treatment department, and then taken back again to cool and to dump. These operations, and the storage and mixing of carburizing compounds, are inherently dirty and dusty, and consequently their removal from the main departments of the factory does much to maintain the scrupulous cleanliness observed everywhere.

A considerable portion of the products of the Heald Machine Co. consists of jigs and fixtures to enable new production work to be ground in machines already in customers' hands. Many parts of these specialties must be heat treated, and consequently the department is continually called upon to harden small lots to special specifications. A fairly large fraction of the metallurgist's time is spent in consultation with the engineering and designing departments, advising as to the proper material and heat treatment to apply to a given part.

His main job, however, is to see to it that defective material never enters the completed machines, months later to cause trouble and dissatisfaction in the purchaser's organization.



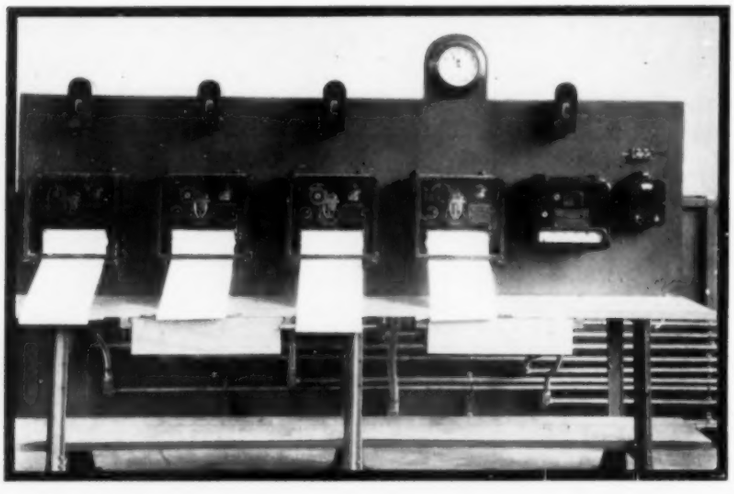
In fact, occasional trouble encountered in the past with the main spindle is the real reason why the metallurgical department was reorganized a year or so ago, and the best of modern equipment installed so that no alibis could be offered from that score.

In the Heald machine, the spindle carries the grinding wheel at its outer end. As close up to the wheel as the reach will permit is a long bearing, two or more times as long as the diameter. Then sufficient space is given for the driving gears, and one or two bearings at the back end complete the length. (Typical spindles are illustrated on the opposite page.)

Old practice was to use a medium hard chrome-manganese steel for these spindles, machined from bars as received from the steel mill (mill annealed). Chemical composition of this open-hearth steel was within these limits: carbon, 0.40 to 0.50; chromium, 0.40 to 0.60; manganese, 0.90 to 1.15.

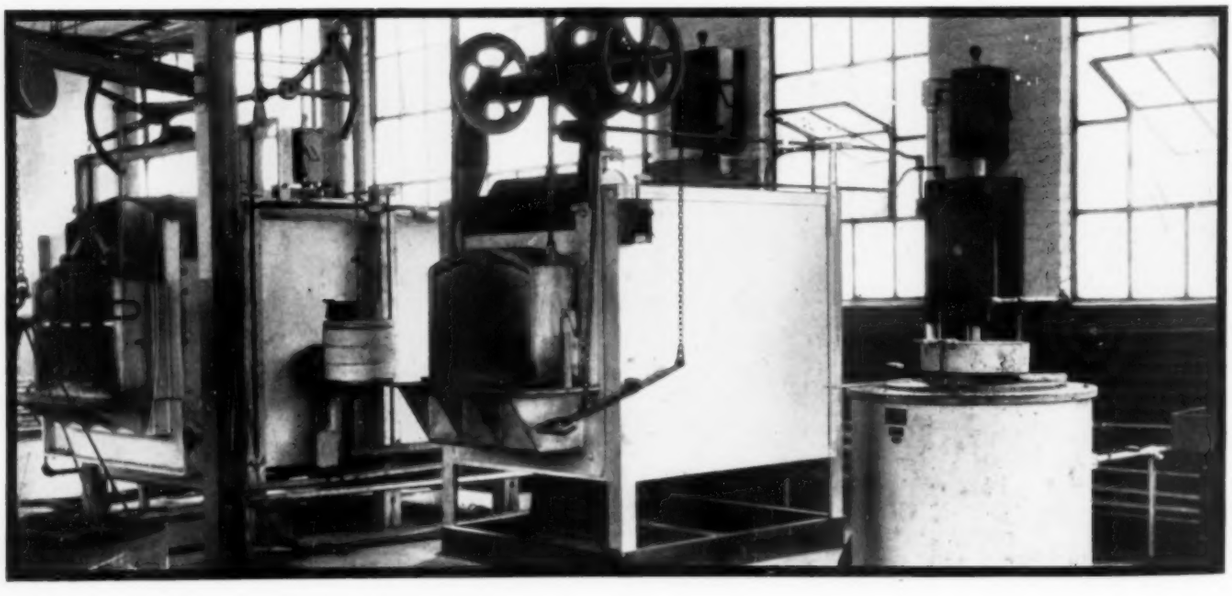
Since only the end bearings of this spindle needed to be hardened, the practice was to place a collar about the body of the machined spindle and hang it through the roof of an oil fired muffle. When properly heated to 1500° F. (as judged by eye) it was oil quenched and drawn at 400° to Rockwell 50 to 55 C. Then they were finish ground and installed in the machine. This method of heating gave spindles requiring little straightening, but had little else to recommend it.

As mentioned above, these spindles, after being in service for several months, would occasionally develop serious defects in the form of longitudinal surface checks in the bearing.



*On the Opposite Page is Shown a Collection of Three Representative Spindles for Precision Grinders. The longest requires a 60x36-in. furnace for heat treatment.*

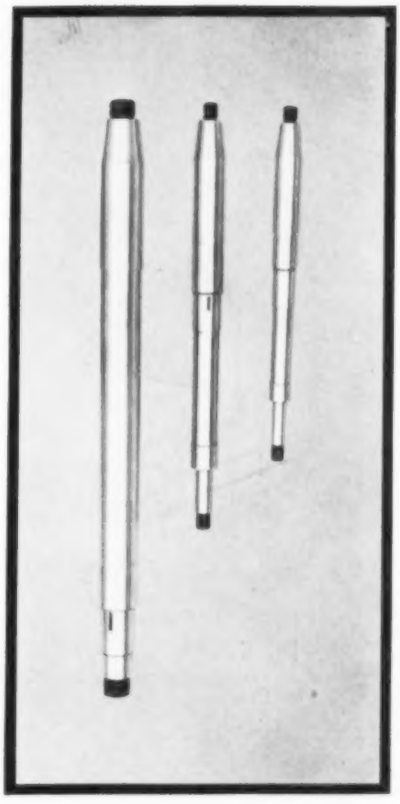
*Automatic Control, Time Clocks, Recording and Indicating Pyrometers Are All Mounted on One Central Instrument Board. Contactor panels are located immediately behind each electric furnace, such equipment being housed in steel cabinets.*



Before many of these would appear, the bronze would fail to lubricate properly, and the spindle would freeze to its bearing. Replacement of both parts would then be required, an expensive and time-consuming job before the new pieces could be secured and installed.

In order to avoid these delays, a cleaner electric furnace chrome-molybdenum steel has been recently specified for the spindles — S. A. E. 4150. This, after quenching in oil at 1625° F. and drawing at 400 will give correct Rockwell hardness, and has so far given satisfactory service. It appears to be tougher steel in the hardened condition, and resists better the mild temperature stresses, edge to center, set up by high speed operation in long bronze bearings. It is definitely cleaner, also, and there appears to be reason for associating the surface checks in the old spindles with tiny inclusions or "snake lines."

Since three-bearing spindles need to be hardened only at the bearings, the other parts of the length are wrapped with several layers of asbestos paper, wired on. This prevents the quick cooling from the quenching heat. Despite the gas curtain on the electric furnaces, the atmosphere is not sufficiently well adjusted to prevent slight decarburization, and it is a matter of greatest importance to these spindles to prevent this action. To prevent soft spots on the hardened surface, the entire shaft is therefore put into a pipe and packed with spent carburizing compound.



Even though the spindles in their containers are carefully blocked on the furnace floor, they may be slightly out of line after being heated in a horizontal position and then quenched, but after minor straightening, they can be cleaned up in the finish grinding operation without difficulty to a dimension well within the close tolerances specified.

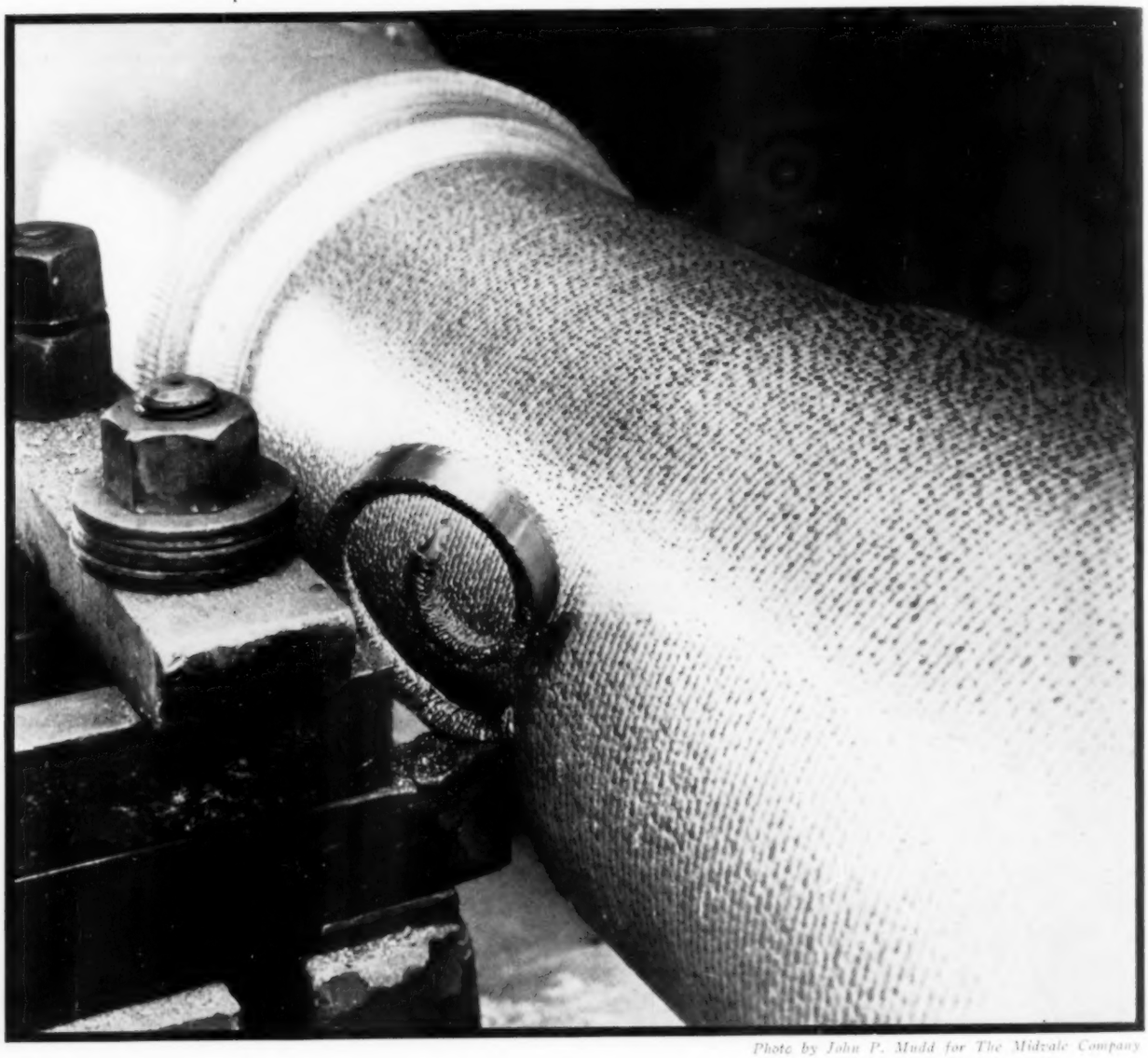


*Photo by John P. Mudd for The Midvale Company*

Hogging off Metal

# Wanted: Data on Cutting Tools

AN ENORMOUS MASS of investigative work has been done, both here and abroad, on the cutting of metal. Scientific work on this complex problem of course dates back 35 years to F. W. Taylor's investigations on air hardening tools, work which can truly be said to introduce an era of the scientific management of mass production, since it led directly to the wide-spread use of high speed steel.

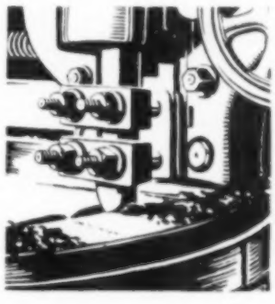
Taylor's brilliant and comprehensive work could not help but set the standard for later investigations. Few who followed in his footsteps have challenged the principles which he established; whatever deviations made in the test procedure were justified by the plea that a complete Taylor test was too expensive and took too long for incidental developments in the metallurgical art, or for comparing steels which varied but little in composition or heat treatment, or for testing a tool for a special purpose such as milling a gear or hogging off metal.

Recent scientific work, especially in England, has been along more fundamental lines, such as studying the stresses in the tool and in the test log, the plastic deformation of the chip, and the mechanism of the cutting action itself. This also is far too abstruse to be applied by the shop or toolroom foreman to the question of how to get the most out of his available equipment. He wishes specific information for specific applications. While the work so far done on the art of cutting metals has resulted in enormous improvements in the general nature of the tools, the work-a-day problems of the shop applications depend upon so many complex variables that a scientific analysis is either impossible or too complex to be useful. Fundamental data are material for the special investigator rather than the general practitioner.

Furthermore, much of the classical work was done under plant conditions which no longer maintain. For instance, when Taylor, White and Barth were in their prime, labor was cheap and power was dear. Now the exact reverse is true — we can lavish energy, but time (especially non-productive time such as used in re-tooling a big automatic machine) must be strictly economized. Sometimes we desire a fine finish more than a high speed. Likewise we have suddenly come to the realization that the metal being cut is by no means as uniform as ordinarily supposed. In proof: Charles E. Wilson, vice-president of General Motors Corporation, has said that shipments of gear steel, substantially equivalent within the limits of accuracy of laboratory test, vary as much as 4 is to 30 in the number of parts cut between regrinds.

The circumstances outlined above indicate that the present utility of our scientific knowledge is sharply restricted and that empirical data on the state of the art could be put to much more immediate and practical use. The worthy suggestion has been made that chapters of the American Society for Steel Treating existing in those localities where a great deal of machining is done, could profitably hold round table discussions on the topic.

The important thing for a meeting of this sort would be to draw out the personal experiences of the members. Each one present should come with notes about one part in production, the nature of the steel, its past history, present hardness and condition, the machine tool used, the cutting medium and speeds. The information would be doubly valuable if an operation which had been changed for the better could be selected, and data on both old and new set-ups be submitted.



It may be objected that an accumulation of information secured in this manner would merely prove what we all know, namely, that there are many ways of doing a thing and doing

it well. The proper rejoinder is that a digest of the data, made by the Recommended Practice Committee, would be of immediate and practical value in appraising the present methods in other shops and in indicating how improvements could be made in specific operations. At present, such information in the hands of the public is so rare as to be practically non-existent.

The Secretary of the Recommended Practice Committee stands ready to supply a stenographer to record the proceedings of such meetings as can be organized this year, and to cooperate in securing a well-informed leader for the discussion.

## Our Own Hall of Fame

A FEW LETTERS have been received from readers of METAL PROGRESS asking that the business connection and position be given with the author's name on the first page of the signed articles. Possibly others have wondered why this time-honored custom has been abandoned.

It is for this reason:

We would like to bring the author face to face with the reader. We would like to give more information than merely his present title. A photograph and a brief biography, prominently displayed in the article, would be the right way to do it, except for the fact that it does seem a trifle incongruous to run the heading of an article in large bold-face type, such as "Cast Iron Pipe," and on the same page print a photograph of the author, who is neither cast, iron, nor pipe!

To avoid discordant notes of this sort, and yet introduce the authors to readers who have not made their acquaintance, METAL PROGRESS has printed a series of thumb-nail sketches beginning on page 20 in the first section of each issue. This will be a regular position, and here, each month, may be found our own hall of fame.

## A Business Upturn Near

THANKSGIVING DAY should help to lift the optimistic spirits of those brave souls who believe that all is not lost when the quotation of their favorite stock sinks to bedrock. Traditionally, it is the day when the Puritan, well aware of the multitude of dangers he had narrowly escaped, devoutly attended a special service to show his satisfaction upon being alive and having enough food, clothing and shelter at his command to enable him to carry on for another year. As life became continually easier, this respite in the struggle for bare existence has evolved (degenerated, if you will) to a day of feasting and football playing. We reserve our stock-taking, our appraisal of the year's performance, our good resolutions, until New Years.

It might be thought that there is now small reason for thankfulness, what with the steel production down to 50% of capacity, metal manufacturing plants operating on 2- or 3-day weeks, grain, cotton and other primary commodities at the lowest price of a generation, and the newspapers carrying daily stories about unemployment and poverty.

But another side of the picture is shown by a list of 9-months' earnings by 100 leading corporations. Comparing 1930 against 1929, one is surprised to find that few of them appear to be in distress. Aside from the profits of the steel industry (whose leaders recently acknowledged themselves to blame) and the automotive industries (also a victim of forced production), most of the figures for this year of panic are fairly close to those for last year, a year of unbounded prosperity! Banks, public utilities, electrical manufacturers, food producers, railroads, mer-

chandising organizations, tobacco manufacturers, household equipment makers, petroleum refiners — such corporate activities have generally been able to maintain their earnings by some means or other.

Evidently the general business situation is not in as bad shape as alarmists would have us believe. Or else a remarkably small drop in expected earnings makes a captain of industry nervous and overcautious.

## Suppressions in Alloy Systems

IT IS UNFORTUNATE that equilibrium diagrams are introduced to most students by way of the phase rule. The phase rule, as you know, is a good deal like the second law of thermodynamics — both are beautiful abstractions, which condense so much into so little that they mean little or nothing to the undergraduate. The result is that too few people have any working knowledge of these alloy diagrams, or appreciate the influence they have had on modern developments in the science of metals.

If teachers of science could be prevailed upon to use these equilibrium diagrams less as gymnasium equipment for budding intelligences and more as work-a-day tools for future production executives, the students would get a much better grasp of the true situation. Especially is this viewpoint desirable since very few of the embryo captains of industry will be researchers, called upon to construct a new diagram from original data, yet many will be superintendents and supervisors, who should be able to use them to correct some minor metallurgical trouble arising in their future practice.

This is not said with any thought of belittling the work of the physical chemist or metallurgist who painstakingly works out the required data. No one whose experience extends back much further than 20 years can help but realize the wonderful advance in the art of working and treatment of metals, an advance impossible except for adequate information about what goes on inside a solid metal during its heat treatment, knowledge which is all compressed in a most remarkable manner in these same equilibrium diagrams. He therefore willingly concedes the importance of those fundamental studies into alloy steel and slag systems now entering the fifth year at Carnegie Institute of Technology and the Pittsburgh station of the Bureau of Mines.

In a group of coordinated studies directed by a metallurgical advisory board (prominent men in the local steel industry) much work is being done on alloys of purest iron and manganese. Various compositions are being studied for the first time, and with the aid of the most advanced microscopic, thermal and radiographic equipment. Repeating the results of cursory investigations made some years back, most authorities state that the two metals form a continuous series of solid solutions. The Pittsburgh studies indicate that it is nearer the truth to say that at least six different phases exist. As Dr. Robert F. Mehl of the Naval Research Laboratory put it, "The Mid-Victorian age in metallography, which was about 1910, comprehended many simple alloy systems. But the X-ray, in the hands of metallographic Freuds, has psycho-analyzed many of these pure series and has proved them to have lamentably complex tendencies and even suppressions!"

Unquestionably, such careful and systematic work on the common steel making metals is fundamental to the rational development, treatment and use of complex alloys for special purposes — a future development which the present can but dimly foreshadow. All the more reason for a pedagogical technique which will present this information in such a form or medium that it can be used by men of tomorrow when the need arises.

# Wear Resistance of nitrided nitralloy

By V. O. Homerberg
and J. P. Walsted

WEAR is sometimes defined as the destructive effect of work and usage. As applied to metals, it is used in the sense of the removal of metal at the surface of a solid by the friction of another body. It is a most commonplace and familiar phenomenon, yet it is really a very complex subject and comparatively little, as yet, is definitely known concerning its exact nature.

Probably more metal articles are ruined or made unserviceable by wear than by any other agent except corrosion. Due to the ever-present tendency for wear to occur when two or more solid bodies in contact move in reference to each other, the problem of defeating wear is widespread.

General conclusions cannot be drawn after the completion of a series of tests, for it is not possible to state that one metal is more resistant to wear than another. It is possible only to point out that under certain conditions one has been shown to be better in certain respects than another.

Evidence of the complexity of the problem of wear is shown by comparing the results of different investigators for the same metal. In many cases the superiority of one over the other depends upon the particular methods used or the particular set of data considered. There is no universal test machine nor test method and technique. It is better to study wear under actual service conditions, if possible, although this process may be a long and expensive one.

In any wear test, it is important to determine whether or not both surfaces are injured, whether seizing, balling, or jumping takes place, and whether the harder or the softer material wears at the greater rate.

In 1929, Lieutenants Kiefer, Crist and Kindell, post graduate students at Massachusetts Institute of Technology, studied the wearing properties of nitrided nitralloy against various alloys. Their problem was a specific one so that the conditions under which the tests were conducted were made to simulate those encountered in service.

The apparatus used in their tests is shown on the opposite page and was adapted from a drill press. A driver with a key-way was designed to take the place of the regular drill. This driver was used to rotate the upper speci-

men. A special shaft was designed to hold the lower specimen. This shaft may rotate easily since it is seated with ball bearings in order to enable the operator to determine the torque caused by the friction. A casting supporting the lower bearing is bolted securely to the drill press table. A small electric tube furnace is shown alongside, which may be placed over the specimens in operation, so the results of friction at elevated temperatures could be observed.

A small sheave was bolted to the bottom of the shaft, and a flexible connection led off to a spring balance by means of an ordinary door spring (in order to damp the vibrations). In this way the torque set up by the friction could be measured. It is equal to the product of the force, measured on the spring balance, by the lever arm, measured by the radius of the sheave. A small steel bar is bolted to this disk to act as a stop so that the machine will continue to function in case the spring should break while the observer is absent.

A thermocouple was led up along the lower shaft and then into the shaft, the exit of the couple being $\frac{1}{16}$-in. from the rubbing surface.

Observations were made at five-hour intervals. Data recorded included the temperature developed by friction, torque, loss in weight, loss in height and the condition of the two surfaces. Sections were examined microscopically after the completion of each test, and the nitrided case at the worn surface was compared with another spot not exposed to the wearing action.

The tests consisted in studying the wear resistance of nitrided nitralloy against itself, gray cast iron, white cast iron, monel and three bronzes.

The coefficient of friction was determined by means of the following formula:

$$T = \frac{2}{3} F W \frac{R^3 - r^3}{R^2 - r^2}$$

$W$ = weight in pounds acting vertically on the wearing surface,

$T$ = torque in inch-pounds,

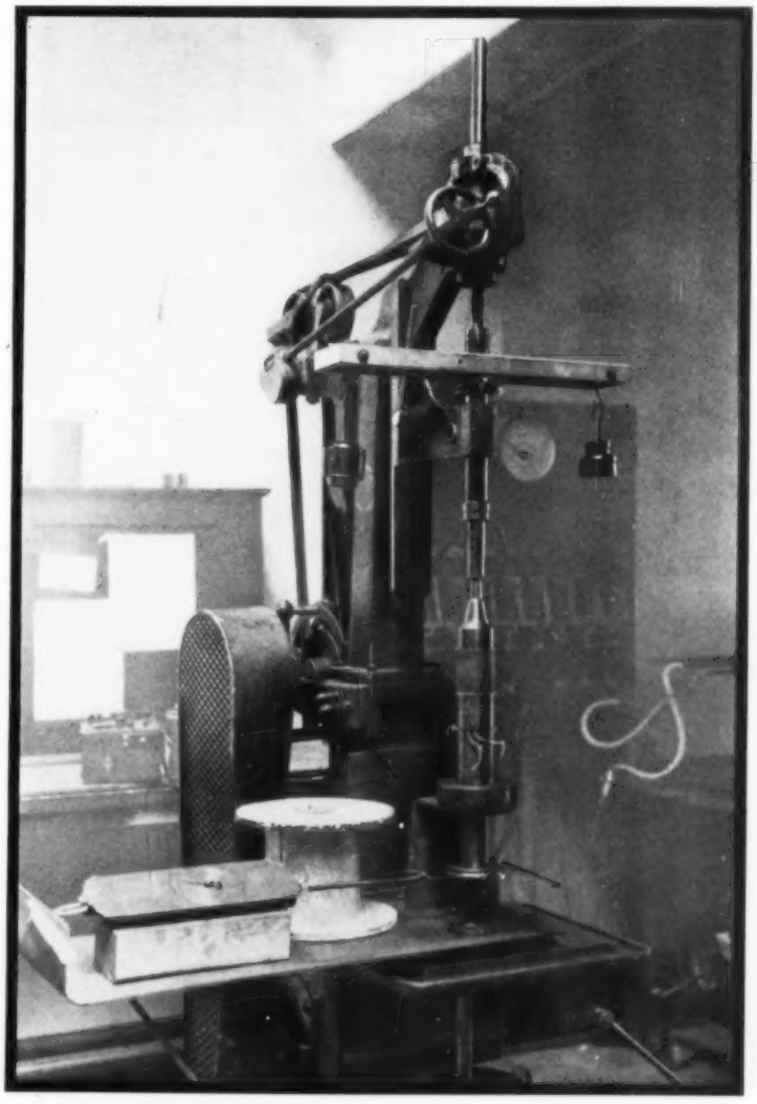
$F$ = coefficient of friction,

$R$ = outside radius of specimen in inches,

$r$ = inner radius of specimen in inches.

The tests described were conducted without lubrication and without the application of external heat.

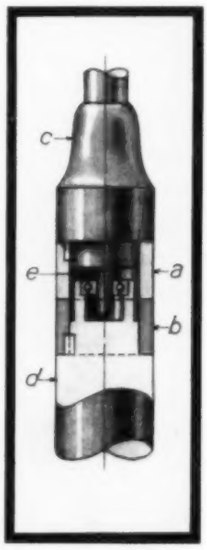
The sketch (center page 70) shows the de-



*Wear Testing Rig Adapted From Drill Press. Fixture attached to tool holder drives a ring edgewise against a similar ring held by vertical shaft. Latter is mounted in ball bearing and torque measured by spring balance.*

tails of the construction at the rubbing surfaces. The upper and lower specimens *(a)* and *(b)* are shown in contact at the lower and upper edge, respectively. *(a)* is fixed to the driving spindle *(c)*; *(b)* is also keyed to the supporting shaft *(d)*.

A center, protruding from the upper driving tool, keeps the upper and lower shafts in line by rotating in the ball race *(e)*, and in this way takes up all side thrusts, prevents wobbling, and insures perfect alignment of moving parts.




Specimens *(a)* and *(b)*, in the form of hollow cylinders, had an outside diameter of 2.5 in., an inside diameter of 1.75 in., and a height of 1⅜ in.

The table below gives the results of the tests in which the nitrided nitralloy was tested against a special bronze, the analysis of which is: Cu 80.2%, Sn 11.5% Ni 5.5%, Zn 2.8%, Pb trace. Its Brinell hardness was 86. During the test fine particles of nitrided nitralloy became embedded in the bronze, but in these tests and in all others, the surfaces were entirely free from scoring. No appreciable decrease in the depth of the nitride case could be noted when examined microscopically, although the measured height of the nitralloy ring was apparently shortened about 0.002 in. Also, the surface hardness of the nitrided specimens was the same after the test as before it was begun.

Tests of nitrided nitralloy against itself and against gray cast iron were run for 20 hr. at 1150 r.p.m., stopping at 5-hr. intervals for observations. Similar data to that shown in the table was gathered on these runs.

In the experiment of nitralloy against itself, the total pressure on the rubbing surfaces was 12 lb. per sq.in. The specimens were finish machined but not polished before nitriding. No lubrication was used, and at the end no scoring could be observed nor any loss of hardness.

The temperature from frictional sources was measured at 400 to 430° F. The readings of the torque, made at 5-hr. intervals, figured to 15, 20, 22 and 14.4 in-lb., corresponding to a friction coefficient of 0.237, 0.316, 0.347 and 0.227 respectively. The total loss in weight of the upper specimen was 2.07 grams; loss in weight of the lower specimen was 1.84 grams.

When nitrided nitralloy was tested in this manner against gray cast iron of 140 Brinell hardness at the same speed, the temperature generated by friction also reached 400 to 425° F. Torque, measured at 5-hr. intervals, figured to 17, 20, 19, and 18 in-lb., corresponding to a friction coefficient of 0.268, 0.316, 0.300 and 0.284 respectively. Total loss in weight of the nitralloy was 0.95 grams; of the cast iron 2.03 grams. No scoring occurred in this test.

Lieutenants Blick and Buracker in a 1930 thesis confirmed the results noted in the foregoing and made further tests by observing the wear resistance of nitrided nitralloy against itself at a temperature of 1000° F. After 13.5 hr. at this temperature (with a total number of revolutions of 858,600) the loss in weight of each specimen was only 0.46 grams, and the coefficient of friction figured to 0.28, which as observed is about the same as the average of the four results noted in the second paragraph above.

Capt. H. V. Hopkins conducted some wear tests in some advanced work done at Massachusetts Institute of Technology early this year by means of the appa-

WEAR TEST, NITRIDED NITRALLOY AGAINST SPECIAL BRONZE

| Elapsed Time, Hours | Final Temperature, °F. | Torque, In-Lb. | Friction Coefficient | Loss in Weight, Grams | | Speed, R.p.m. | Total Revolutions |
|---|---|---|---|---|---|---|---|
| | | | | Nitralloy | Bronze | | |
| 5 | 200 | 16.6 | 0.262 | 0.279 | 0.030 | 300 | 90,000 |
| 10 | 205 | 14.0 | 0.221 | 0.306 | 0.020 | 300 | 180,000 |
| 15 | 320 | 12.0 | 0.190 | 0.078 | 0.130 | 1150 | 525,000 |
| 20 | 275 | 6.0 | 0.095 | 0.000 | 0.132 | 1150 | 870,000 |
| 25 | 240 | 6.0 | 0.095 | 0.000 | 0.116 | 1150 | 1,215,000 |
| 30 | 250 | 6.0 | 0.095 | 0.065 | 0.110 | 1150 | 1,560,000 |
| | | | Total: | 0.73 | 0.54 | | |

ratus shown at the bottom of this page. The machine is provided with a variable speed motor and with a reciprocating mechanism whereby two specimens can be rubbed against each under a desired load. The specimens were 2x1x½ in. The stroke of the machine is two inches so that the specimens were rubbed together with a variation of contact area of one to two square inches. The pressure on the areas in contact, therefore, was twice as great at the end of the stroke as it was at midstroke.

The load was applied through a lever mechanism with a sliding weight similar to the beam of a balance scale. A handle operating a screw permitted vertical adjustment of the lever, to compensate for the wear and for the varying thicknesses of specimens in order to maintain the lever in a horizontal position and to maintain a constant load. The load mechanism permitted a range of loads from 13 to 150 lb. at will.

All specimens were accurately cut to size and ground, and rubbing surfaces were finished on a fine emery belt. This finish approached the average commercial surfaces for bearing purposes.

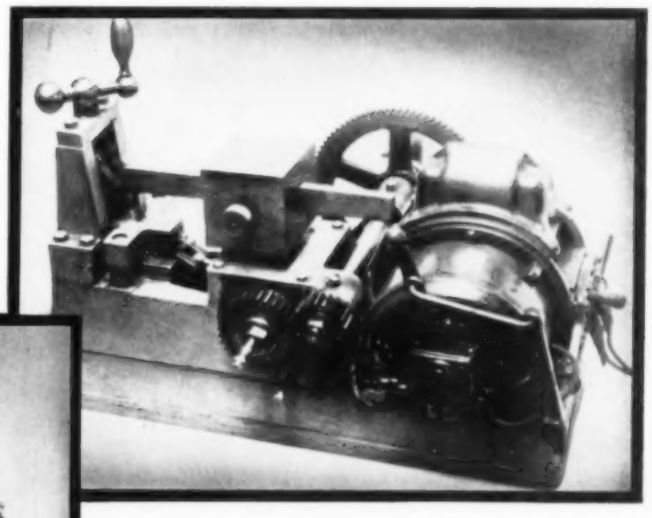
The specimens were washed in alcohol to remove grease or oil and carefully brushed to remove dirt.

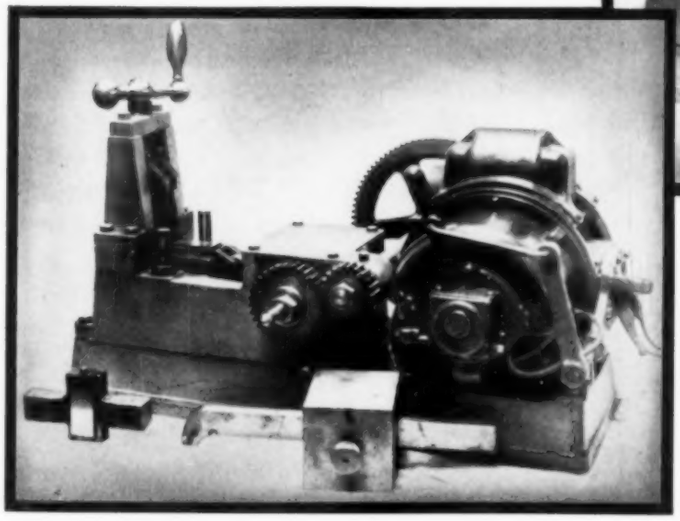
The machine was stopped at minute intervals up to 5 min. after rubbing had commenced in order to examine the surfaces. Additional observations were made at 5-min. intervals throughout the test. Special observations were made in order to ascertain the causes, whenever seizing, jumping or squeaking commenced or whenever the machine slowed down or speeded up. Visual examinations of the surfaces were made by a binocular microscope.

The contact surfaces were observed during the rubbing operation by means of reflected light to observe excessive filming or balling-up of the material, as seen by the separation and the lifting apart of the surfaces. All tests were conducted without lubrication.

In this work approximately 60 combinations of materials were tested at room temperature without lubrication. Combinations of materials such as were used by Kiefer, Crist and Kindell, and later by Blick and Buracker, were run in this machine by Captain Hopkins with results which checked closely with those obtained in the former tests.

From the results of these tests, it is indicated that the use of nitrided materials in engine or machine parts, which are subject to severe wear conditions and are difficult to lubricate, offers great possibilities.

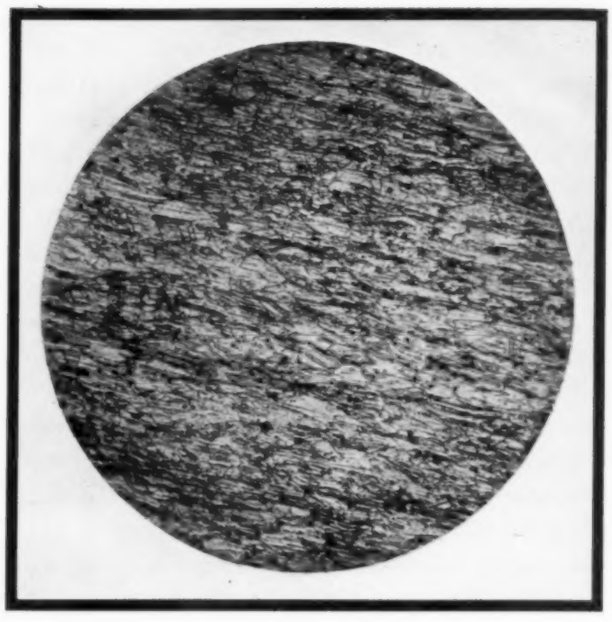




*Machine For Rubbing Flat Surfaces Against Each Other. In one view the loading lever and the holder for the upper specimen are removed and appear in the foreground. Method of assembly is obvious from an examination of the other view.*

*A Note Prepared for Nonferrous Data Sheet Committee, Institute of Metals Division, A.I.M.M.E., and Recommended Practice Committee, A.S.S.T.*

# Etching Nickel and its alloys



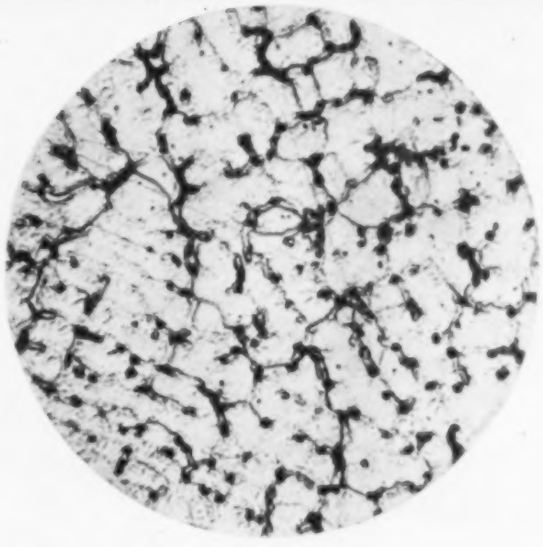
By W. A. Mudge

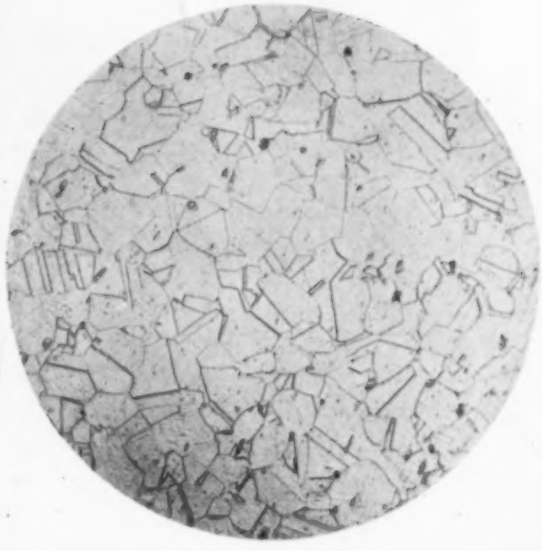
NICKEL, monel metal, and other nickel-copper alloys may be most satisfactorily etched for microscopic examination with nitric acid solutions. Two solutions have been found to give excellent results with both cast and wrought products:

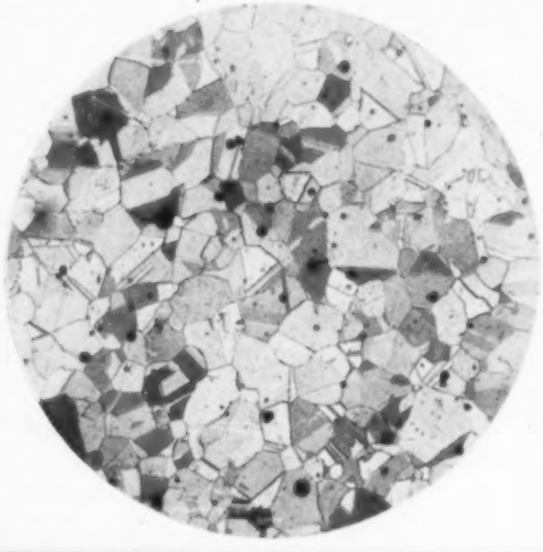
*Flat Etching Solution.* This is made by mixing equal parts of concentrated nitric acid and glacial acetic acid. Time of etching a sample will vary from 5 to 20 sec. depending upon the nickel content of the alloy and the depth of etch required. The higher nickel content requires the longer time for a satisfactory contrast. Dilution with from 25 to 50% of acetone is quite desirable when the nickel content of the particular alloy amounts to less than 25%.

*Electrolytic Contrast Etching Solution.* Use the following formula: 10 cc. concentrated nitric acid; 5 cc. glacial acetic acid; 85 cc. water. This solution should be used with a 1.5-volt dry cell and platinum wires. Time required is 20 to 60 sec. Over-etching should be avoided as it will invariably result in deep pitting.

In order to avoid staining of the specimen, particularly when using the flat etch, only clear, white nitric acid should be used in making the solutions, and it should be freshly made daily. Best results are obtained at room temperatures. After etching, the specimen should be thoroughly washed with water and alcohol and dried quickly







*Cold Rolled Monel, Etched With Flat Solution. Shown at Top of Page 72.*

*Cast Monel Metal: Sample at top left is etched with the electrolytic solution, and the same casting etched with flat solution, is shown at top right.*

*Annealed Nickel: View at right (center) is etched with the flat solution; below it is another spot etched with electrolytic solution.*

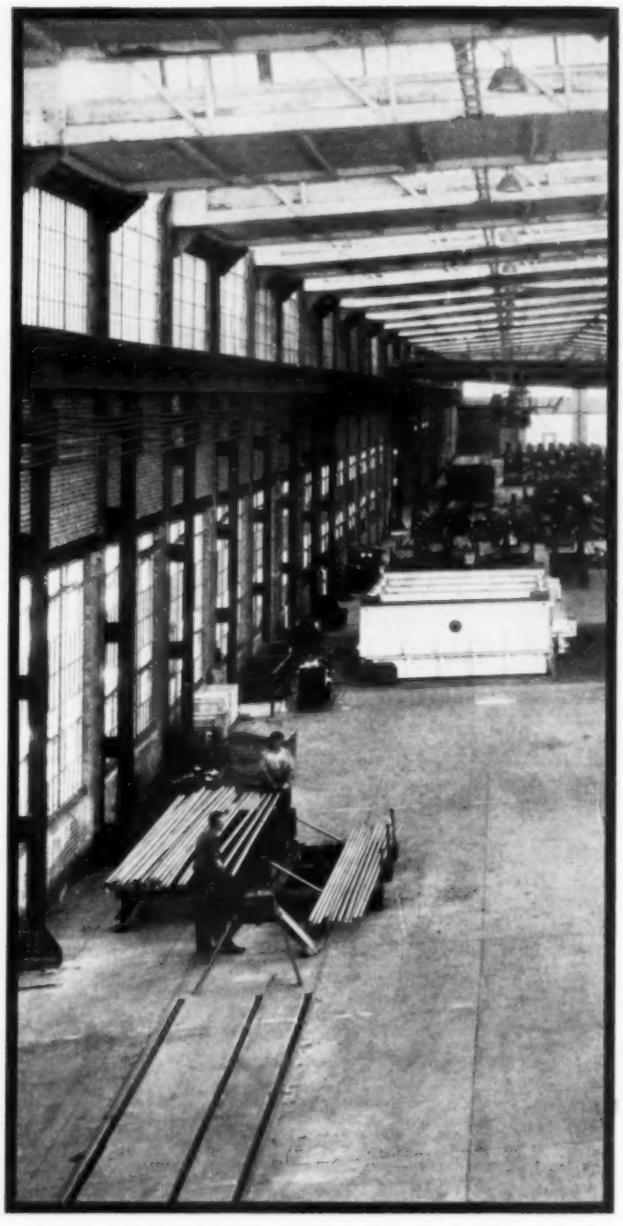
with a clean air blast. If a few stains are present in the flat-etched specimen, they may be removed by wiping with a clean, smooth cloth or cotton.

The electrolytic contrast solution will stain less than the flat solution and further cleaning will not be necessary. It is definitely superior to the concentrated hydrochloric acid solution often recommended.

Each of these two solutions serves a particular purpose. The flat solution offers the better opportunity for the detection of sonims, flaws, and porosity. Good results with heavily cold worked material are obtained only with it.

The electrolytic contrast solution is more satisfactory for uniformity of grain size.

Modern labor saving equipment of large capacity a feature.

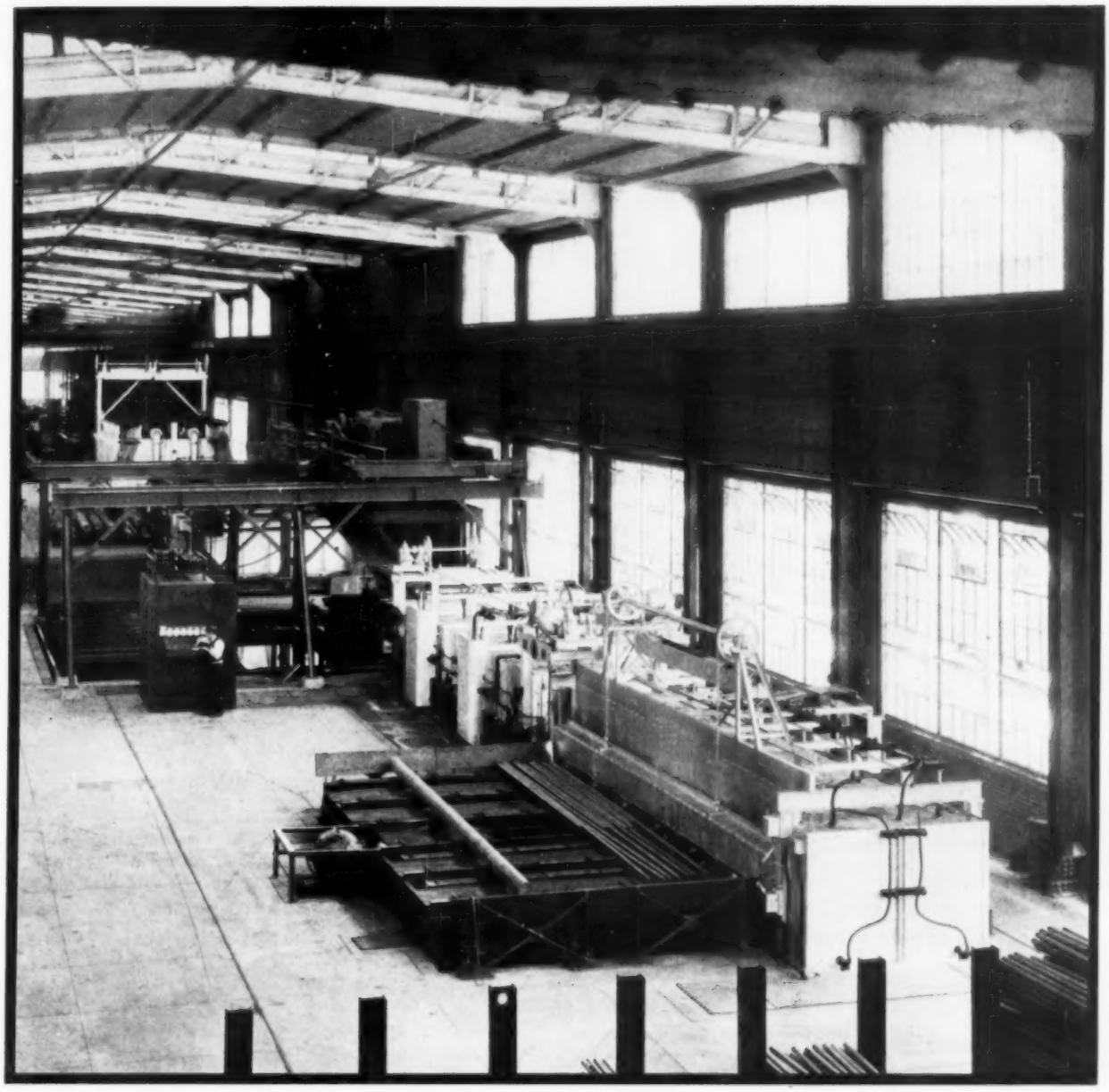


# Bethlehem's heat treatment shop

by S. D. Gladding

OVER ITS LONG HISTORY, Bethlehem Steel Co. has given particular attention to scientific advance. The Taylor and White developments in alloys, the production of the Grey beam and other pioneer efforts have convinced the company of the soundness of keeping in the forefront of production methods.

In line with this policy, an electric heat treating shop has been built to meet the demands of modern markets, where specifications are becoming more and more rigid. Accuracy, ease of application, and uniformity are obtainable in marked degree by the equipment installed through this modern shop, and enable



*Views of Heat Treating Shop From Raw Material Racks. In immediate foreground above is a preheating furnace, charged automatically with a batch of bars through a side door. Continuous roller line advances warmed metal endwise into high heat furnace just beyond, and at proper time out far end into a quenching machine shown in more detail on page 76.*

us to satisfy the demands on a sizable production basis.

Bars of any composition or section from ¼ to 8 in. and any length up to 25 ft. can be uniformly normalized, annealed, quenched and tempered to meet physical properties consistent with quality and section.

This recent installation is housed in a new building 67 ft. wide by 820 ft. long, so constructed that there is the maximum amount of daylight through windows in the roof, sides and end walls. The building is itself a notable advance in construction over many older heat treatment shops in the steel industry, where it seems the designer strove for darkness rather than light.

The layout is designed for the most rapid routing of bars through the shop consistent with good heat treatment; therefore, sequence of operations has been given closest study.

Major equipment consists of one roller hearth furnace for heating prior to normalizing or quenching, two pit furnaces for annealing, two car bottom furnaces for annealing, skids leading to Brinell machines, three round bar straighteners, two seven-roll straighteners, one gag straightener, one rough turning machine and two inserted tooth saws.

The entire area is spanned by two overhead travel-bridge cranes, and the layout is so made that the capacity can be doubled by the installation of appropriate furnaces.

A track long enough to hold three standard gage cars enters the west end of the shop. Bars come from the rolling mills, loaded on flat cars or gondolas in bundles and are unloaded by overhead crane and placed either into a furnace or in storage racks to await their turn.

Next in line, from west to east, is the roller hearth furnace for heating for quenching or normalizing. It is shown in the foreground of the view on page 75, and consists of two chambers, placed end to end. The first is a side-charged preheating chamber operating at 800° F., and the second a high temperature chamber which operates at the desired temperature for quenching or normalizing. Each of these chambers is 29 ft. long and 5 ft. wide inside. Hot bars are handled on one continuous roller line through the preheating chamber and the high temperature chamber and out alongside the quenching tank. The outgoing end of the preheating chamber and both ends of the high temperature chamber have lift doors.

This tandem furnace has the capacity to heat 6,000 lb. per hr. of 3-in. round bars 25 ft. long to a temperature of 1650° F. (Bars may be of any section from ¼ in. to 8 in.) A charging mechanism is provided for the preheating chamber, having space for two loads of material. A lift door is built into one side of the preheating chamber which, when raised, allows a charge to be automatically placed on the rolls in this chamber.

When hot steel is discharged through the east end of the high temperature chamber, a low-level crane lifts the work off the roller line and places it in the quenching tank by means of the nest of bales shown in the view below. The electrical control of this crane is arranged so that it automatically places the bars in the quenching tank, raises and lowers them to avoid steam pockets and to give a uniform quench.

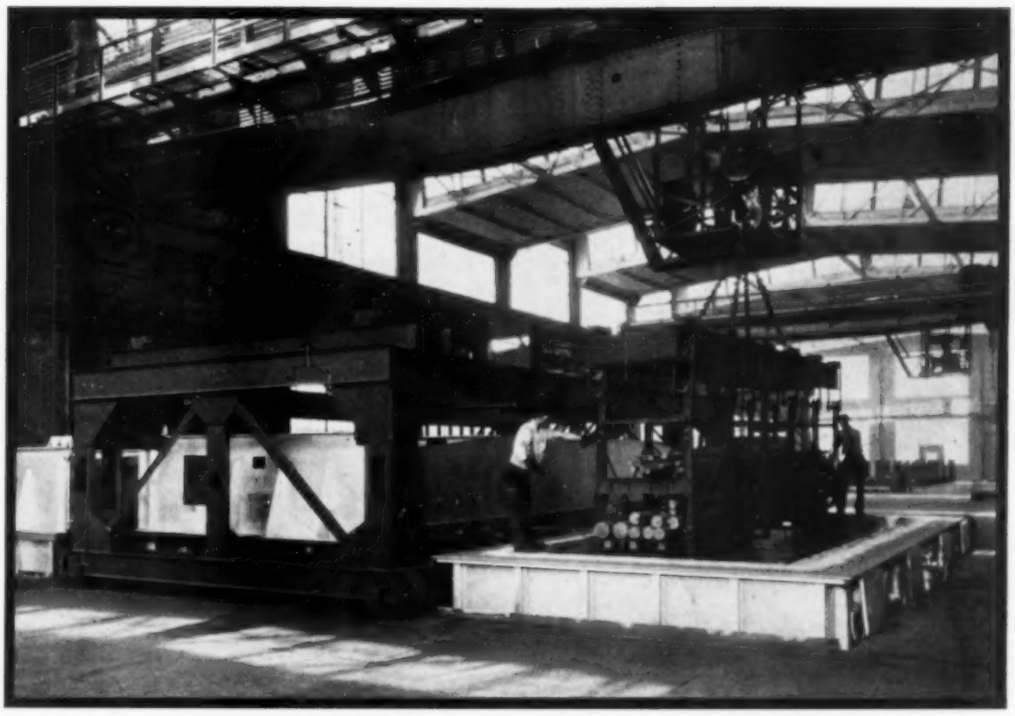
### Five Seconds, Furnace to Quench

With this equipment the time required to get the bars out of the furnace and into the quenching medium is five to six seconds, so that the drop in temperature of the bars before reaching the liquid is very slight. Length of time in the quenching medium is also controlled by a time switch; when the time is up, the crane lifts the bars out of the tank and places them on unloading skids, and automatically returns to its original position ready to take the next discharge. If the bars are to be normalized, the control is switched so the crane will lift the bars off the discharge roll table and deposit them on the unloading skids, thus by-passing the quenching tank entirely.

Either water or oil may be used in the quenching tank. The sides and ends of this tank are lined with 2-in. pipes through which cooled water is circulated, so the medium is never above room temperature when a quench is about to be made.

A charge for this tandem furnace con-

*Bars From the Heating Furnace Are Rolled Endwise Out the Door and Come to Rest Above the Horizontal Prongs of the Quenching Bale. The latter lifts them and in 5 sec. they are either being swished up and down in the tank or are resting on racks for slow cooling. All motions are automatic.*



*Pair of Annealing Pits With Space Between Them to Deposit the Cover of a Furnace When it is Being Loaded. Racks, built of heat resisting alloy, hold 50 tons of bars, and are rapidly raised or lowered into furnace. Damage to heating elements is prevented by guides built into walls, matching stanchions on the racks.*

sists of the number of bars it will take to spread, without having one on top of the other, across the roller line. This figures to 26,000 lb. for six bars 8 in. diameter, 25 ft. long.

The roller line through the furnaces is connected with a single motor for synchronous movement and electrical control is so arranged that when a charge is being heated the rolls oscillate back and forth 180° eight times each minute. Due to this fact, the same spot on the bar is never in contact with the supporting rolls more than ⅛ of a minute at any time during heating, and the possibility of cold spots is entirely eliminated, and a uniform heat throughout the length of the bar is insured.

### Automatic Timing Switches

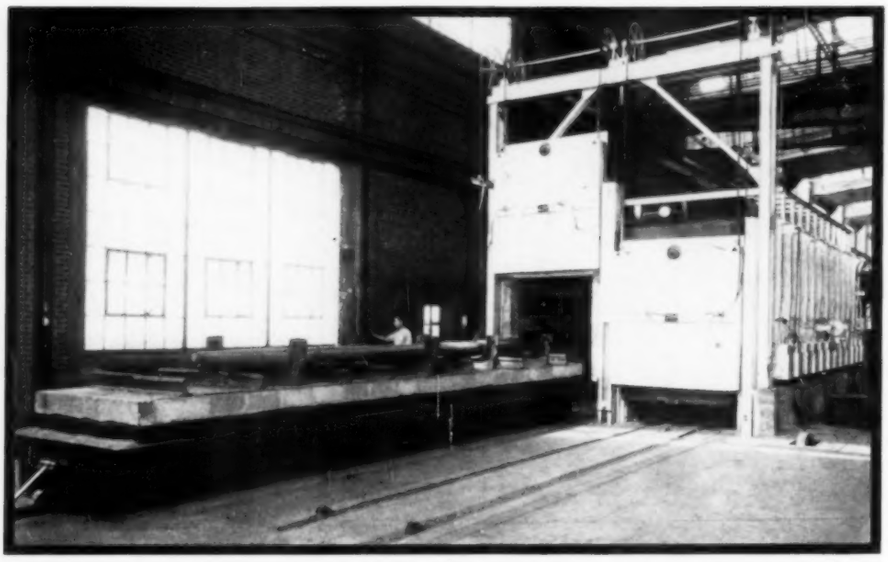
All of these operations are controlled automatically from a master timing switch, which is adjustable over a wide range for different sizes of stock which require different times in the furnace.

When starting operations a charge is placed in the preheating and high temperature chambers by the use of hand-operated switches. Sequence of operations is as follows for the second and subsequent charges:

1. End doors raise.
2. Roll table starts forward.
3. Roll table stops when charge has been run out. At the same time, the crane for quenching starts to lift and the charging mechanism for placing a charge in the preheater starts to operate. When the charge is run out of the high temperature chamber, the charge in the preheater takes its place.
4. End doors close.

The operation of quenching and charging the preheater will be taking place at the same time. Describing them separately, taking the sequence of quenching first:

1. Crane lifts the charge of bars from the roll table.
2. The crane travels sidewise over to the quenching tank.
3. Crane lowers the charge in the quenching medium and oscillates up and down by



*Car Bottom Furnaces Have a Common Center Wall. Six-wheel cars are run in and out by rack and pinion drive. Car tops are of flat plates of heat resisting alloys, protecting heating elements below. Heating elements are also arranged on doors and side walls. Load is supported on appropriate yokes.*

limit switches for a definite time, determined by a timing relay which is set for the time desired in the quenching fluid.

4. Crane raises material out of quenching fluid and travels to the unloading skids.

5. Crane lowers cold material on the unloading skids.

6. Crane travels back to the original position, ready for the next load of hot bars.

The sequence of operation of the charging mechanism, when charging bars into the preheating chamber, is as follows:

1. Side door raises.

2. Bars are raised off the loading rack.

3. Charging carriage advances, carrying the bars into the furnace.

4. Charging carriage lowers and deposits bars on rolls inside the preheater.

5. Charging carriage moves out of the preheating chamber.

6. Side door closes.

7. The roller line in the furnace starts to oscillate through 180 .

The preheating chamber is constructed with brick walls 10 in. thick, the inner course being of semi-refractory brick and the outer course of heat insulating brick. The roof is arched. Heating units are supported in the roof and below the rolls forming the hearth.

The high temperature chamber is constructed with brick walls 13½ in. thick (4½ in. of firebrick and the remainder of insulating brick). The roof is arched and heating units are supported in the roof, on the side walls and under the rolls. Both chambers are built inside a steel plate casing and a framework of I-beams.

All the doors have machined contact surfaces on both the door and frame. Doors are inclined to the vertical, so they rest against the frames in all positions. Sand seals are provided at the top and bottom.

In the preheating chamber the heating units are divided into two sections, rated at 400 kw. Three similar sections of resistor loops contained in the high temperature chamber are rated at 576 kw. Temperature is controlled by five indicating temperature controllers, one in each section, and registered on a six-point recorder. Power measuring instruments have also been provided, so the energy consumption per ton of steel treated may be determined when desired.

Two pit annealing furnaces are next in line. Cover of one of them is shown in the middle distance in the head-piece. These have a capacity of 50 tons each; the heating chamber is a rectangular pit with inside clearance 27 ft. x 8 ft. 6 in. x 7 ft. deep. Six piers extend cross-

wise of the furnace at the bottom for supporting the charge. Walls are 18 in. thick, half of semi-refractory brick, and the outer half of heat insulating brick, the whole built inside a steel plate casing with I-beam framework. The bottom is raised above the floor of the containing pit to prevent entrance of moisture.

As shown in the view on page 77, the cover consists of a rigid structural steel framework lined with a brick arch extending crosswise of the furnace. A stiff-legged gantry crane is provided to raise the covers and move them to one side, depositing them between the two furnaces when charging or discharging a load from the pit. A channel filled with sand on top of the furnace walls and a blade on the under side of the cover provide an adequate seal.

### Rapid Transfer of Load

In order to prevent the waste of power, furnaces are charged and discharged as quickly as possible. To facilitate this, racks made of heat resisting steel are provided to hold the charge. By this method, a lift by one traveling crane discharges the furnace, and the second crane lowers a new load in place.

The supporting piers are capped with heat resisting alloy for the cradle to rest upon, and guard bars of similar material are placed along the side walls to guide the load and to prevent it from damaging heating units and side walls. In addition, a row of heavy firebrick tile is securely anchored to the steel casing, and extends completely around the top of the pit to prevent injury to the walls by accidental contact with the load when raising or lowering. The guard bars are supported from these tiles, the lower ends extending into sockets in the piers and free to expand and contract with temperature changes.

Heating elements in each pit are divided into six zones, three lengthwise and two high, each zone being controlled by indicating and recording equipment. Heating units are placed on the side walls and on each face of each supporting pier. The units have a total capacity of 1,098 kw.

The cooling rate of these well insulated furnaces is very slow, being only 6 to 10° per hr. between 1,450 and 1,000° F. This extremely slow rate is very seldom needed, and in order to accelerate it without admitting air to the furnace, cooling pipes of heat resisting alloy are built into the cover. Air is blown through these pipes from a blower and duct system. These pipes, laid crosswise, are spaced 9 in. apart for the entire length of the cover, the air entering one end of the pipe and discharging from the other open end into the room. This method of cooling will provide any rate from 10 to 60° F. per hour.

Even more rapid cooling may be had by opening blast gates which are spaced 2 ft. apart along each side of the furnace. These will allow air to circulate through the heating chamber by convection.

These furnaces are constructed so that when the steel begins to show color an analysis of the atmosphere in the furnace will show 0.5% of oxygen, which will eliminate scaling during the anneal.

Next in line of operation are the two car bottom furnaces shown on the opposite page. Two chambers are built in one shell with a common center wall. Each chamber has inside clearance dimensions of 26 ft. 6 in. x 5 ft. x 4 ft. 9 in. high.

Two 6-wheel cars (with roller bearings) are provided for each chamber. They have smooth tops made of plates of heat resisting alloy extending the full length and width of the platform. Retaining angles of cast iron are placed around the edges to hold the supporting brickwork in correct position.

Sand seals are provided along both sides of the cars and one across the front end to engage the blades on the bottom of the doors, there being also another on the back of the furnace which engages when the car is pushed in.

### Cars Driven By Rack and Pinon

Cars are operated in and out of the furnace by motor driven spur gears, engaging racks mounted on the under side of the car framework, and extending the full length.

Heating units are mounted on both side walls of each chamber, on the back wall and door, and in the car platform underneath the hearth plates. Terminals for the latter units are connected to bars mounted on the cars.

When the car is in the in position these engage resilient contact shoes mounted on the furnace walls below the heating chamber. Channel shaped pans are provided at all points in the hearth plates to prevent scale or dust from reaching the heating units underneath.

The doors and door frames are cast iron. The doors are inclined to the vertical, and machined surfaces on both doors and frames insure that they are tight at all times. Sand seals are provided at the top and bottom. Flexible connections are provided to the heating units mounted on the doors, so it is not necessary to disconnect them when raising the furnace doors.

These furnaces are also built in a plate steel casing with a framework of I-beams. Side walls are 10 in. thick, the inner lining being semi-refractory and the remainder heat insulating brick. The division wall is 18 in. thick, with 9 in. of insulating brick in the center. The arch is 9 in. thick. Auxiliary cooling pipes are installed, similar to those in the pit furnaces. U-shaped heat resisting alloy cradles have also been provided for handling the bars in these two furnaces.

Heating units are divided into three zones in each chamber, each zone controlled by an indicating controller. A four-point recording pyrometer records the temperatures in each chamber. The total capacity of the units in each chamber is 675 kw.

Heating units in all furnaces consist of heavy strips of nickel-chromium resistance material formed into sinuous loops, spaced approximately 1½ in., and supported by molded hangers of refractory insulating material. Terminals extending through the walls are of double thickness and are incased in heavy bushings of heat resisting insulation.

### Centralized Control

All the electrical control is mounted in a small two-story annex, the electrical control being on the first floor and the pyrometer equipment on the second floor, with telephone connection to each furnace.

At the bottom of this page is a glimpse of the finishing and inspecting departments. Brinell testing machines have handling tables and roller lines to facilitate testing. Next in line are three round bar straighteners which take bars from ¼ to 6 in. diameter. Following this are flat straighteners, a gag straightener, saws and rough turning machines. Altogether there is equipment to straighten and machine cut any section up to the equivalent in cross-section of an 8½-in. round. Ample space is held for storage racks for bars ready to ship.

All material going through the shop receives individual and careful study in each successive operation through the heat treating, testing, straightening, turning, cutting and shipping, by a man thoroughly experienced in his duties. As a check upon the operating force, men from the general metallurgical department are in the shop at all times, continually checking the orders as to customers' requirements and satisfying themselves that these are met.

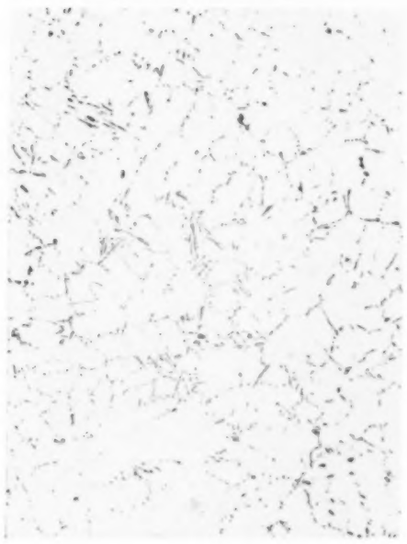
*Finishing Department Is Well Equipped With Roller Tables and Storage Racks to Avoid Undue Labor. Straighteners, cut-off saws, rough turning machines and Brinell hardness testers are installed.*

# Sand Cast Aluminum-Silicon Alloys

**Normal Structure**

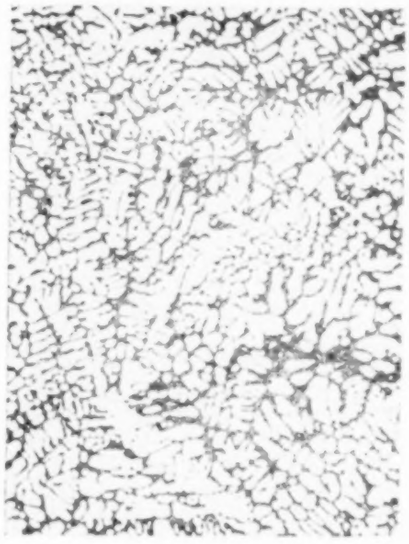
**Modified With Sodium**

All of ½-In. Test Bars, as Cast in Green Sand. Relatively pure metal was used in order to simplify the microstructure. Magnified 75 times, except as noted.

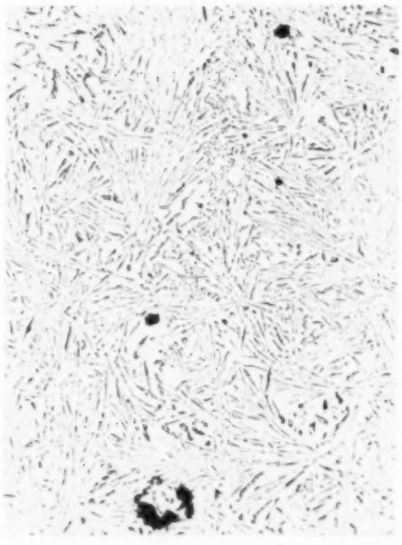


## Silicon 5%

Silicon 5.0%; iron 0.24%; copper 0.07%. In the aluminum-silicon eutectic which occurs between the grains or dendrite branches, the silicon is in the form of comparatively large plates or needles which appear dark in the micrograph. Specimen unetched.



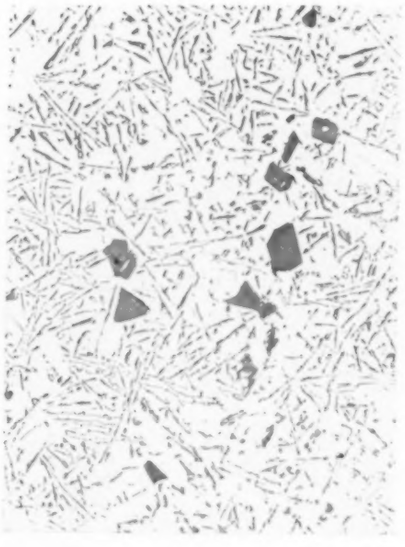
Silicon 5.0%; iron 0.04%; copper 0.02%. The structure of the aluminum-silicon eutectic has been greatly refined as seen by comparison with the opposite micro. This alteration in the eutectic structure renders the dendritic structure of the aluminum more apparent. Specimen etched with aqueous solution containing 5% HF and 10% $HNO_3$.



## Silicon 13%

Silicon 13.2%; iron 0.3%; copper 0.04%. This structure consists largely of the normal aluminum-silicon eutectic with silicon in needle or plate form. The alloy is slightly hyper-eutectic as shown by occasional dark particles of primary silicon approximately equi-axed in shape. The half-tone thread-like constituent near the center of the micrograph is a ternary aluminum-silicon-iron constituent called $\beta$(Fe-Si) by Dix. Specimen etched in aqueous solution of 0.5% HF.

Silicon 12.75%. Primary aluminum dendrites (white) in a matrix of the modified aluminum-silicon eutectic (dark). This photograph is somewhat unusual in the clearness with which the different orientations of the dendritic grains of the casting are revealed by differences in tint. Etched in aqueous solution containing 5% HF and 10% $HNO_3$. Magnified 15 times.



## Silicon 14%

Silicon 14%; iron 0.03%; copper 0.02%. Substantially equi-axed particles of primary silicon in matrix of normal aluminum-silicon eutectic. Unetched.

Silicon 14.0%; iron 0.37%; copper 0.02%. The substantial absence of either primary aluminum or primary silicon is to be noted, showing that the composition of this alloy is approximately that of what may be termed the "modified" eutectic. Unetched.

*Photomicrographs by Aluminum Research Laboratories, Cleveland.*

# 25 LBS. TO LIFT INSTEAD OF 50

Alcoa Aluminum is used in these No. 3 Cincinnati Millers for removable arbor supports and motor compartment cover.

## How The Cincinnati Milling Machine Co. greatly reduced weight of removable arbor supports

Here is another actual instance of how the light, strong Alloys of Alcoa Aluminum are relieving machines of excess dead-weight—of how resistance in selling is cut because the eventual owners of the machines can operate them faster.

Made of cast iron the removable arbor supports of the No. 3 Cincinnati Milling Machine weigh about 50 lbs. each. Cast in the light, strong Alloys of Alcoa Aluminum these supports weigh about 25 lbs. each. On many jobs there are two of these supports to be taken off and put on. With the new Alcoa Aluminum supports the operator now has 50 lbs. less to handle.

The weight of the No. 3 Cincinnati Millers is further reduced by the use of motor compartment covers cast of Alcoa Aluminum. For large machines these new covers, in Alcoa Aluminum, weigh about 50 lbs. each. The old cast iron covers weighed about 200 lbs. each.

Hundreds of products have been benefited by the use of Alcoa Aluminum Alloys. Sales resistance has been cut as products have been freed of many pounds of costly dead-weight. Very likely the light, strong Alloys of Alcoa Aluminum can be used in your products to great advantage. They are as easy to fabricate as steel.

## Send for these 3 books—they're FREE

One book tells how to Rivet Aluminum.

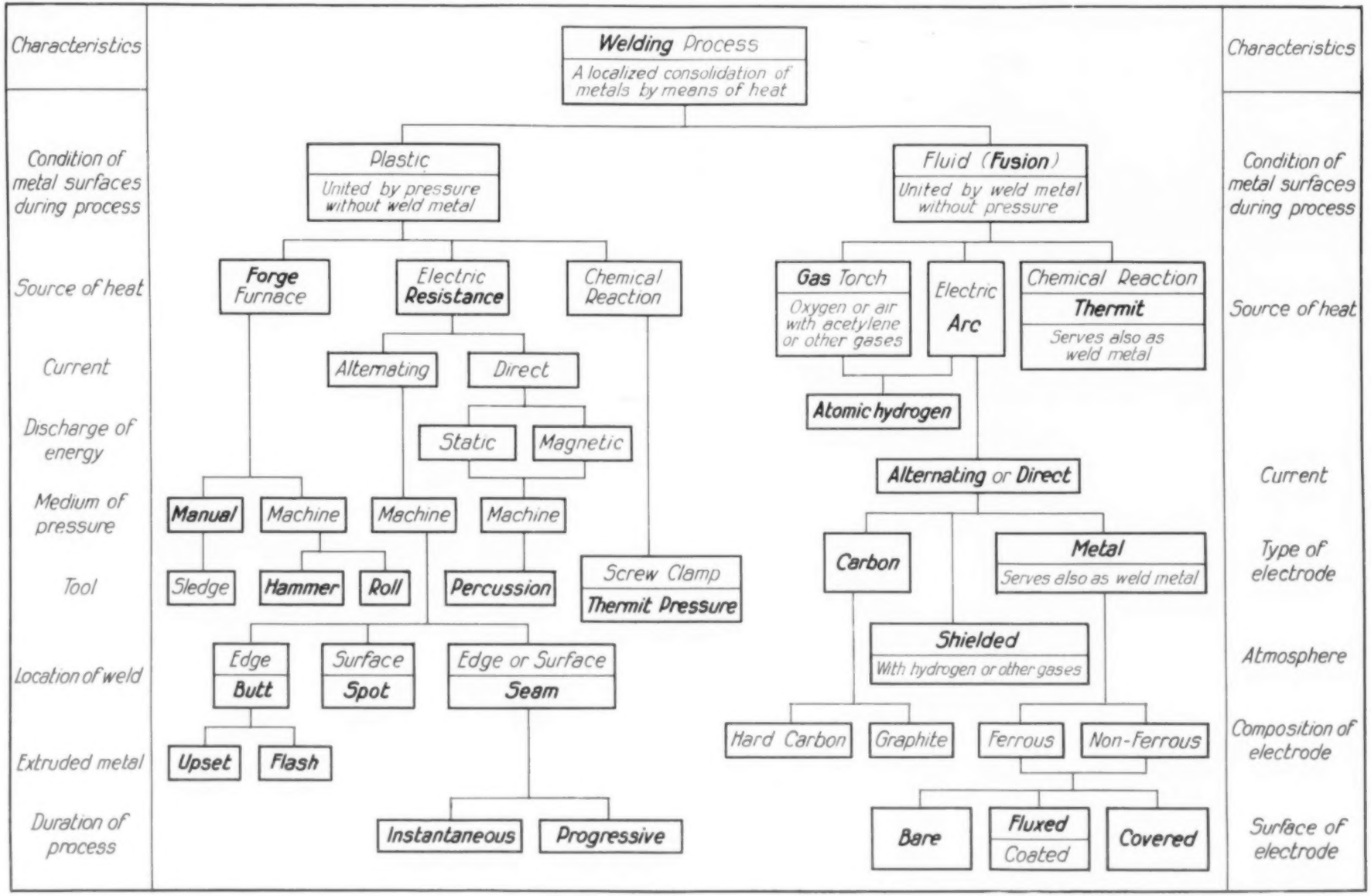
Another book deals with the Welding of Aluminum.

The third book covers Aluminum Screw Machine Products.

If you wish one or all three of these books address your request to ALUMINUM COMPANY *of* AMERICA; 2501 Oliver Building, PITTSBURGH, PENNSYLVANIA.

# ALCOA ALUMINUM

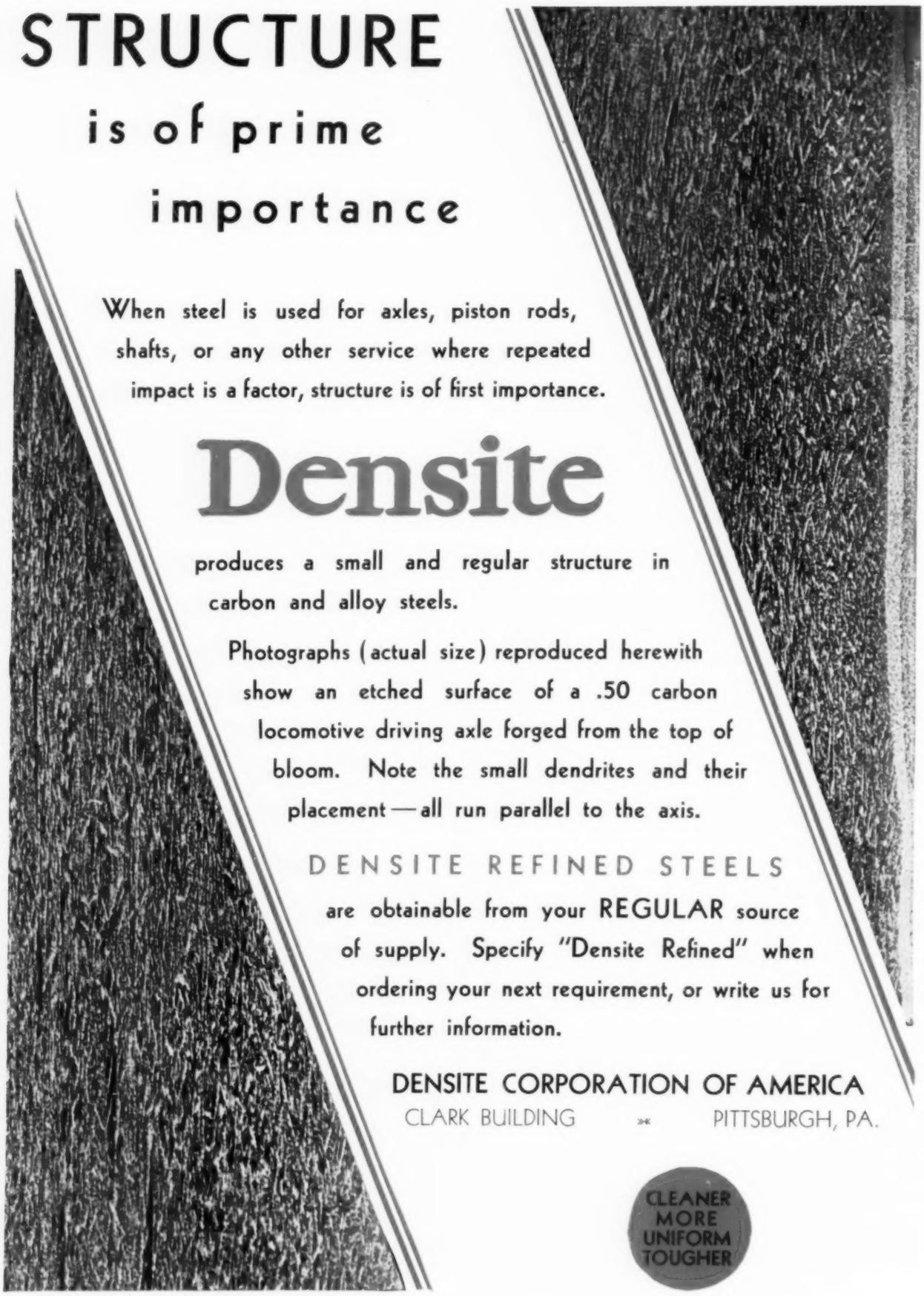
# CHART CLASSIFYING THE PRINCIPAL WELDING PROCESSES




Classification Made By F. T. Llewellyn. See page 95.

# STRUCTURE

## is of prime importance



When steel is used for axles, piston rods, shafts, or any other service where repeated impact is a factor, structure is of first importance.

# Densite

produces a small and regular structure in carbon and alloy steels.

Photographs (actual size) reproduced herewith show an etched surface of a .50 carbon locomotive driving axle forged from the top of bloom. Note the small dendrites and their placement — all run parallel to the axis.

DENSITE REFINED STEELS

are obtainable from your **REGULAR** source of supply. Specify "Densite Refined" when ordering your next requirement, or write us for further information.

**DENSITE CORPORATION OF AMERICA**

CLARK BUILDING ✻ PITTSBURGH, PA.

CLEANER
MORE
UNIFORM
TOUGHER

## Roller Bearings in Swedish Mills

HAVING DONE a great deal of work upon the construction of ball bearings or roller bearings able to stand the high loads and heavy shocks of the kind delivered to the axles of railway cars, the SKF company of Gothenburg has also turned its attention to the question of rational bearings for rolling mill machinery. The latter activity began about ten years ago with some preliminary experiments at Hofors, in its own steel works, when comprehensive pressure measurements and tests on a number of different types of bearings were started. Finally, a spherical double row roller bearing, like those introduced by the company in the railway field, was found to give good results when used for this new purpose.

Since then, the plant at Hofors has been gradually equipped with roller bearings until now a wire mill, consisting of roughing mill and finishing rolls (the last housing of a three-high mill), a 14-in. intermediate train and a tube mill have all been furnished with bearings of this kind.

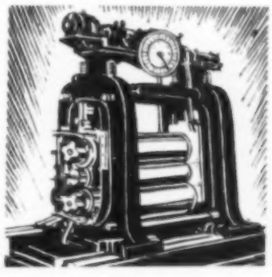
During these years quite a number of other steel works have also placed roller bearings in their rolling mills, and a great deal of experience concerning the value of this machine element for the purpose in question has now been gained. The leader of SKF's developmental work in this domain, Gunnar Palmgren, has related his experiences at some recent metallurgical meetings in Sweden.

Roller bearings have always proved to be of a very high strength and to have great resistance against wear; practically all the bearings which were originally mounted are still in use. Continuity in production has thus been very much increased, since unintentional interruptions occur more seldem. Less scrap (out-of-gage material) has been made.

Power consumption has decreased 35 to 40% in the roughing and intermediate mills, somewhat more than 40% in the finishing and wire mills, and 45 to 50% in the strip mills. Since new bushings for the old-fashioned bearings are no longer needed and the lubrication costs are reduced to a trifle, the total saving through the introduction of roller bearings has been so great that the cost of this improvement in the old machinery may be paid off within a year.

When constructing a new mill with roller bearings, motors and drives may be dimensioned for turning moments 35 to 40% smaller than those needed when bronze boxes are used. Reduction in such costs more than counterbalances the added expense of the more expensive roller bearings; thus, a reversable roughing mill is after all cheaper to build with roller than with bronze-lined bearings.

Introduction of roller bearings has also produced a very marked advance in the technique of cold rolling, especially because the well-known construction of small working rolls backed up by rolls of large diameter requires constant attention if built with the conventional bearing liners. Owing to the permanence of roller bearings, this trouble and expense are avoided and most of the cold rolling firms in this country as well as many works abroad, have introduced new trains of this kind. Recently one was built here for cold rolling hard alloyed steel in widths up to 30 in.



Strip production is much increased, since the machinery may be operated at an increased velocity, and can reduce the gage of the material a greater amount in each pass. The product also comes out more uniform in gage, end to end and edge to edge.

Finally, the saving of power required to drive a cold mill amounts to about 50%.

In view of all these facts it may indeed be stated that the contribution of the Swedish

bearing industry to the development of rolling mill technique has been of much importance.

A. WESTGREN

Stockholm, Sweden.

P. S. I was much interested in the letter from A. H. Alexander in the September number of your review. The knife marked "Morakniven" is from Mora, a parish in Dalecarlia in the center of Sweden. Its population has been famous many hundred years for its love of liberty and its independence. It is also well known for its great handiness in making good knives. The Mora knives are made by unlearned village smiths who have inherited their art through many generations.

## Thin Plates in Peace and War

I HAVE SOME NOTES on the production and properties of sheet steel and thin plates, as used in the arts of peace and also for wartime purposes.

First about tin plate — mostly used for food containers. Ten years ago, the tin plate used in our country was imported, mostly from America. Since that time, the Yawata Imperial Steel Works in Kyushu has been developing its manufacture and in the last few years, the annual production has been about 45,000 tons. Since the present annual consumption of tin plate is about 75,000 tons, only a fraction of it need now be imported.

Kawasaki Dock Yard Co., of Kobé, has also installed sheet mills and thin plate mills. It, too, has been successful in marketing its output to the extent of about 100,000 tons a year. A minor portion of sheet and thin plate from Kawasaki is galvanized in small factories in Osaka and Tokio.

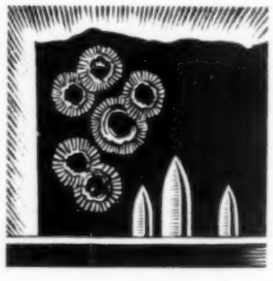
The writer, in association with Genzo Takemaé and Tyokko Watanabé, has been studying the protective efficiency of steel and other metal plates against penetration by rifle bullets. Heavy armor for protecting battleships or gun emplacements is usually of nickel-chromium steel, with a carburized and hardened face, but the light armor for tanks, field guns or helmets must be a homogeneous toughened material. Preferably it should be capable of cold forming and be machinable, yet highly resistant to sudden impact. In the past this has been secured by steels, martensitic after air cooling.

In our studies we measured the energy absorbed from a flying bullet during passage through the plate. This energy can be figured from the difference of velocity before and after penetration.

For measuring the residual velocity of the bullet after passing through the plate, the bullet strikes a sand box, suspended as a ballistic pendulum from the ceiling. The velocity of the bullet is proportional to the displacement of the box. Since this is quite small, it is magnified about ten times as is done by a seismograph, measured and compared to a blank test by a bullet of known velocity. It is an easy and accurate method, needing no complicated electrical devices.

Plates of different thickness were shot at, and the residual velocity plotted against the thickness. Curves for several metals were determined; they also give the thickness of a plate of a material which is just sufficient to stop the bullet. Some interesting conclusions deduced from our investigation are:

1. An efficient armor must possess great hardness combined with toughness. In plain steel and many other metals, hardness is associated with brittleness, so a good material must be sought among the special steels.



2. The best material found by us is a heat treated nickel-chromium steel. A 9-gram bullet at 790 meters per sec. is stopped by a 4.5 mm. plate (0.18 in.).

3. A single plate is more efficient than a laminated plate of equivalent thickness.

4. Two plates of equal thickness separated from each other are better than a single plate of equivalent thickness; the effect of separation is greater as the distance increases.

K. HONDA

Sendai, Japan.

## Italy is now Making Alloy Steels and Iron

DURING THE EUROPEAN WAR, the Ansaldo company of Genoa had started to develop a deposit of magnetite at Cogne, in the western Alps at an elevation of 7,500 ft. The ore is very pure, and had long been used as a source of high-quality iron from small charcoal blast furnaces. Some equipment was installed for transporting this ore to Aosta (at 1,800 ft. elevation), where Ansaldo had erected electric reduction furnaces and a steel plant.

This property, including four hydro-electric power stations, was purchased in 1923 by the Società Anonima Nazionale Cogne, newly organized by the Italian government for the purposes outlined in my last letter. The large anthracite deposits at La Thuille, 35 km. from Aosta, were also acquired.

Essential units of these properties for the manufacture of semi-finished products were rapidly completed. By the middle of 1924, two electric reduction furnaces were working regularly, and at the end of the same year, the steel works (including four 25-ton electric furnaces) and four rolling mills were also in full operation. The steel works used, in this first period, special steel scrap purchased outside, and the iron produced by the two electric reduction furnaces.

The products of the Aosta works were immediately appraised as equal or better than the best foreign special steels, both for their excellent quality and for their uniformity. They were adopted exclusively by almost all the Italian engineering works, and for the most rigid requirements.

In the following two years, ore concentrating and sintering plants, blast furnaces, bessemer converters and power plants were completed. There have now been in operation for about five years the following:

1. Four hydro-electric power stations, totaling 60,000 kw.

2. Anthracite mines include two aerial tramways and a 35-km. standard-gage railway to Aosta. The coal is a very good reducing agent for the blast furnaces, and an excellent fuel for the other departments. Large concentration and briquetting plants, to improve the quality still further, are now building.

3. Iron mines at Cogne can produce twice the tonnage now consumed, but sufficient when the new plants are completed.

4. Ore grinding, concentrating and sintering plants are located in Aosta. The Cockerill process has been adopted, which can easily give a sinter containing over 67% of metallic iron. It has been found that 62% iron is best for economic working in the blast furnaces, under the conditions at Aosta.

5. Two electric reduction furnaces, 6,000 kw. each, for producing 100 tons of high-quality special pig iron daily.

6. Two blast furnaces for producing 500 to 600 tons of pig iron per day. Almost all this iron is treated in the bessemer and electric steel works.

7. A bessemer steel plant, including a 400-ton mixer, electrically heated (this being, as far as I know, the first mixer of this type existing in Europe), and three 12-ton acid converters. Most of the bessemer steel is charged liquid into electric steel furnaces for refining and finishing.

8. An electric steel plant, including four 25-ton, one 7-ton, one 3-ton, and one 1-ton furnaces. All work normally in duplex, using the liquid bessemer steel. Only enough of the heats are made from solid or mixed charges to remelt the plant's own special steel scrap. Carbon steel crop ends and own scrap are charged in the blast furnaces and reclaimed.

9. A group of rolling mills, including a 40-in. reversing blooming mill, a 26-in. three-high blooming mill, an 18-in. three-high finishing mill, a double-duo mill (12 in.), and a wire rod mill. Furnaces, except the soaking pits, burn pulverized anthracite.

10. A heat treating plant, including 12 large furnaces, 10x20 ft. hearth.

11. A forging plant with two 500-ton and one 1,000-ton presses, and a drop forging plant

for small pieces containing 12 steam hammers of small and medium size.

12. An iron foundry and a steel foundry.

13. A machine shop for roughing some of the rolled, forged and cast products.

14. Chemical, physical and micrographic laboratories.

In addition to these plants, in full operation, there are now being completed plate and sheet mills, tube mills, cold rolling mills, wire drawing plants, and a forge plant for large press work.

It should be emphasized in this connection that the production of these works — which can reach 15,000 tons a month — is strictly limited to special iron and special steels.

FEDERICO GIOLITTI

Turin, Italy.

## Rapid Estimation of Alloying Metals

QUANTITATIVE ANALYSIS by means of the spectroscope has been widely adopted in certain of the non-ferrous metal industries. For the determination of small quantities of impurities in zinc, brass and tungsten, it has proved to be both more rapid and accurate than chemical analysis. So far as the European steel industry is concerned, the spectroscope has hitherto found its chief application in the rapid determination of the approximate quantities of nickel and chromium in steel bars, as a convenient means of sorting different varieties of engineering steel. For this purpose it has been regularly used in many works.

More refined applications have been attempted in various laboratories, but have not become generally known. At the Prague meeting of the Iron & Steel Institute in September, F. Twyman described a systematic series of experiments to determine the range of applicability of the method. He used a Hilger quartz spectrograph and a rotating logarithmic wedge sector. In such equipment the length of the lines increases with the percentage of the corresponding metal, and it may be calibrated by alloys of accurately known composition.

A series of special steels was prepared and rolled into bars, the chemical analyses being made at the University of Sheffield. Observations were then made for each element, with a view to determining the length of line for a given percentage of each element, and also to fix the upper limit of usefulness.

So far satisfactory results have been obtained with silicon, chromium, nickel and copper. About half an hour is required to obtain a complete record, and each constituent can be measured from the spectrogram in five minutes. Silicon can be determined up to 0.8%, with an accuracy of 10% of the content. Determinations of chromium may be made up to 4%, of nickel to 5% and of copper to 1% or more, all with an accuracy of 5%.

It appears that the determinations of molybdenum and vanadium are also satisfactory, but a larger number of analyses will be required. Manganese has given rather erratic results, but it seems likely that this difficulty can be overcome. So far, it does not seem probable that carbon, sulphur or phosphorus can be readily measured spectrographically.

It remains to be seen how generally this method of analysis will be adopted, but the results are undoubtedly promising, and in the analysis of complex steels containing several of the rarer metals it may well be that the spectrograph will have decided advantages over chemical analysis.

Much interest was also aroused at the Prague meeting by a paper by D. F. Campbell on high frequency induction furnaces. The use of such furnaces for the manufacture of alloy steels is now thoroughly established and furnaces up to about 1½-ton capacity have proved very satisfactory in use. The author of the paper looks forward to the manufacture of steels in large quantity in 10-ton furnaces. He has even worked out the capital and running costs of such a plant in comparison with open-hearth furnaces, the small capacity being more than balanced by the rapidity of action and by

the small size of the ladles and handling plant required.

Hitherto high frequency furnaces have been mainly used for melting purposes only, but experiments in England and in Germany have shown that refining can be carried out in a remarkably short time owing to the intimate contact between metal and slag brought about by the circulation under the influence of the induced field. On the large scale, the furnaces would not be used for melting, but would be charged with liquid metal from a mixer, and the rapid refining would allow of a large production from comparatively small units.

The suggestion is a bold one, but such rapid progress has been made in the use of induction furnaces since the introduction of the Ajax-Northrup type that even such a revolutionary suggestion deserves consideration. The very great thermal efficiency and the remarkable cleanliness of induction heating make the prospect of using furnaces of this type an attractive one, and the question of practicability is one which cannot be answered off-hand.

CECIL H. DESCH

Sheffield, England.

## Foreign Cooperation in Metallography

IN THE PRESENT DEVELOPMENT of our physical and chemical knowledge, the scientific study of metals and alloys (a branch of study called in French "metallographie", in English "metallography" or sometimes "physical metallurgy", and in German "metallkunde") stands in the first rank.

Immediately after the War, metallographical activity suddenly sprang into life and made rapid progress; new fires of research were lit in several countries. Sometimes these activities centered in institutes financed by contributions from an enterprising group of manufacturers; sometimes in private laboratories belonging to factories or metallurgical firms. Some of them employ a considerable number of investigators and are organized into a veritable "research works".

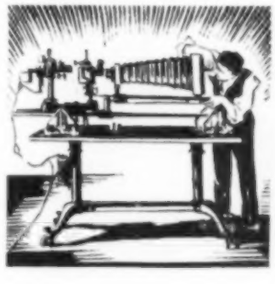
Their production is issued by bulletins or publications created especially for the purpose and reproduced in part or analyzed in numerous periodicals (of very unequal value) devoted to metallurgy or sundry metal industries, or to other branches of physical science.

It is, therefore, extremely difficult, if not impossible, now-a-days, to keep one's self informed about all metallographical progress. Before undertaking a serious study of any problem, a considerable amount of bibliographical investigation must be done.

This library work is often neglected, and that is why some centers of research seem to be unacquainted with investigations carried out elsewhere. This is much to be regretted, since it frequently causes unconscious violation of the traditional ethics of science, and also because it involves much waste time and leads to useless or erroneous experiments. Such lost motion is doubly regretable because the improvement of laboratory equipment and the required technical precision require an experimentalist highly trained, often by a lengthy education in a narrow specialty. Therefore, the operation of our laboratories becomes more expensive day by day, and waste of precious time is to be avoided.

Consequently, it appears very desirable to organize a clearing house for researchers and laboratories so they may all be informed of the work under way, be able to extend mutual services, and propose and undertake joint studies.

A forward step in this direction has taken the shape of an International Association for Metallography. This movement started last September at Düsseldorf, where some English, German and French metallographists met for an interchange of ideas. It was proposed that in every country there be published annually an account of the work done and in progress of a metallographical nature. It should be written by one or several men of standing in each nation, and the material should be coordinated by an International Com-



mission and sent to other nations to be translated and published there. It was also the consensus that metallographists should foregather at international meetings, so they might know each other better and thus help each other.

One must not forget that the various civilized races and nations possess to very different degrees those qualities that secure progress in scientific research, qualities such as imagination and ingenuity, skill, scientific method and discipline, organization and steadiness of purpose, perspicacity and deduction in construing the results. These qualities complement each other; to have only a few of them is not enough to secure leadership in science.

Some notable discoveries have been made with rudimentary devices used by exceptionally clever experimenters; others sprang from a long series of persevering researches requiring generous financial expenditures. Such an interchange of ideas as proposed should do much to supplement and supply known deficiencies in personnel and equipment.

ALBERT PORTEVIN

Paris, France.

## Does Quenching Stiffen a Spring?

IN AN ARTICLE on the metal used for fine springs appeared in METAL PROGRESS for October. It was written by the editor from notes accumulated during an extensive study of wire, prompted by the failure of heat treated wire when used in suspension bridges.

Shortly after its publication, A. L. Boegehold, metallurgist in the research laboratories, General Motors Corporation, Detroit, questioned the statement made on page 34, "that the loading characteristics of a steel spring depend entirely on its shape and dimensions, and cannot be modified by alloying or heat treatment."

Mr. Boegehold continues:

"This, of course, is true of hardened and drawn springs but is not correct if springs are made from cold drawn wire or from heat treated wire. We know that cold working decreases the modulus of elasticity of steel, and that subsequent tempering to sufficiently high temperatures restores it to 30,000,000. Therefore, a spring wound from heat treated wire or from cold drawn wire such as music wire will have its loading changed by tempering.

"It was a common practice, when making gun springs of music wire, to heat them up for a short period of time to about 675° F. and water quench. This treatment very materially increased the load carrying ability per unit deflection, and has been used for many years."

In order that this question might be cleared up by an authority, it was put to F. P. Zimmerli, chief engineer, Barnes-Gibson-Raymond, Inc., Detroit. His comment follows:

"Mr. Boegehold believes that your statement about the loading characteristics of springs being independent of heat treatment is approximately correct only when the material is hardened and drawn after coiling. As the stresses in helical compression or extension springs are largely torsional, I will devote my remarks entirely to torsional characteristics of wire.

"For the practical purposes of spring making, the ratio of stress to strain (Young's modulus) is a constant, although the torsional modulus varies with temperature, and apparently with the amount of cold work which has been given the wire. It consequently appears to change as wire is drawn smaller, and the change is particularly evident in music wire.

"Barnes-Gibson-Raymond has done considerable research work on this property of materials at the University of Michigan. In general, the results show that the torsional modulus of the smaller sizes of wire —say below ⅜ in.— is about 11,500,000. On larger sizes up to 2 in. round, more accurate calculations of the spring performance can be made (especially if the spring is hot wound and heat treated) by using 10,500,000 lb. per sq. in. All cold worked wires give what we can consider a false modulus, inasmuch as a slight temperature change will affect it. The charts reported to the A.S.T.M. in June show that at *(Continued on page 116)*

# Acceptance tests of Gear Steel

• • include

Cleanliness

Normality

Grain Size

Hardenability

BROWN-LIPE-CHAPIN Division of General Motors Corporation, Syracuse, N. Y., manufacturers of high grade gears and automobile transmissions, convinced by long experience that it takes excellent metal to make an excellent gear, has developed an elaborate system of steel inspection before acceptance of shipments from the mill. Volume of production is large enough so that ordinarily entire heats are purchased. After delivery to the forge plant, the material is segregated, and each billet is stamped with an appropriate code number, which number follows any parts made therefrom throughout the entire process of manufacture.

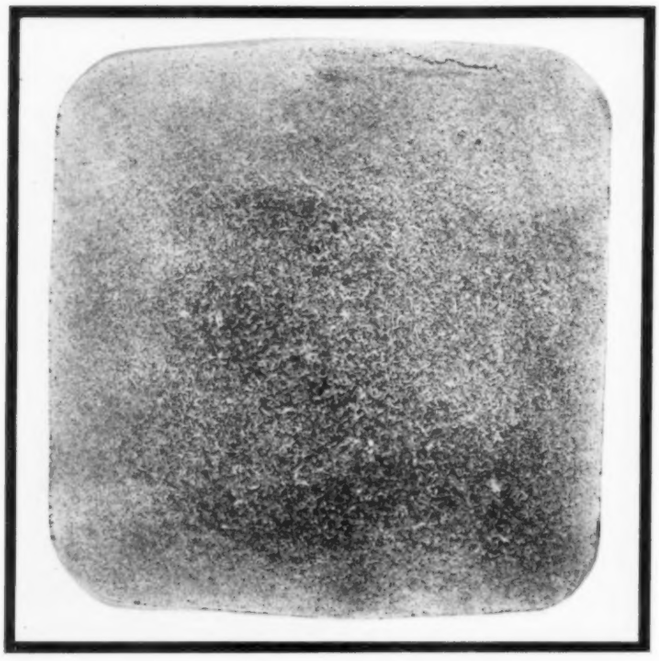
Either open-hearth or electric furnace steel will be accepted without distinction for the numerous varieties of carbon and alloy steels purchased. An exception to this is the 5% nickel steel, used for truck and heavy duty pinions, for which electric steel is used. Established sources of supply furnish the laboratory in Syracuse with three samples — short billet or bar croppings from different parts of the heat, and from top, middle and bottom of the ingot. If the steel mill has not yet furnished metal of consistently high grade for a long enough period of time to be ranked as an "established" source of supply, many more samples carefully selected from the shipment, will be required.

First, each billet is drilled and a complete chemical analysis is made. The usual tolerances are permitted except in carbon; specifications for all types of steel limit the carbon range to five points. For instance, S.A.E. 2315 (which represents the bulk of the consumption by Brown-Lipe-Chapin) has limits as follows:

| | |
|---|---|
| Carbon | 0.13 to 0.18% |
| Manganese | 0.30 to 0.60% |
| Sulphur | 0.050% maximum |
| Phosphorus | 0.045% maximum |
| Silicon | 0.15 to 0.30% |
| Nickel | 3.25 to 3.75% |
| Chromium | 0.20% maximum |

As a matter of fact, nine-tenths of the steel accepted from established sources of supply has carbon ranges from 0.14 to 0.16%.

If the chemical analysis for any element is as much as 0.01% over or under the specification, a check analysis is procured from an



*At Left Is Shown a Good Billet Except for a Crack Near Edge*

outside laboratory, and if the latter's figure verifies the first findings, the steel is not accepted — metallurgists for the purchaser feeling that this first requirement of good steelmaking certainly should be fulfilled.

Chromium is placed at 0.20% maximum in all carbon and alloy steels purchased (which do not contain a specified amount of this element as an alloy) because with this chemical control a more uniform hardening practice can be maintained, and also because more than this amount of chromium affects the machinability of annealed forgings adversely. Amounts of chromium actually found in the analysis range from 0.01 to 0.10%, evidently picked up from remelted alloy scrap.

The above analyses are made before acceptance of the heat of steel. When forgings are delivered to the heat treating department for annealing, drillings are made on each hundredth one, and an estimation of carbon and nickel is made on each sample by the colorimetric process. This, to make sure that no mixture of raw material has occurred in the storage yard.

Brinell tests are also made on the billet samples as received. This is a more important test for the straight carbon and low alloy steels, which are not annealed before machining, than for the 3½% and the 5% nickel steels.

To determine the cleanliness of the steel, a small cube is cut in such a way that a longitudinal section, halfway from center to edge of the sample, can be polished and examined. The entire area of this unetched surface is explored at 100 magnifications to get an idea of the number and size of the inclusions. Then certain questionable areas, if such there be, are examined in more detail at 400 magnifications, and by this means a ready differentiation of the dirt into oxide particles, manganese sulphide, or silicates can be made.

No standards of cleanliness have as yet been set by the Brown-Lipe-Chapin laboratory — at least, in the way of arranging photomicrographs in order of increasing dirtiness and marking a limit between acceptable and unacceptable steel. Borderline cases are rather rare. When they occur, and the steel seems to be acceptable on other counts, the metallurgical engineer and his assistant make an independent appraisal and are usually in agreement as to whether the metal can be classed as satisfactory or as unsatisfactody. Steel mills which are among the established sources of supply very rarely offer a heat which is questionable as to its cleanliness; mills which are not yet on the "established" list are much more frequent offenders.

*Steel Must Carburize Uniformly.* Somewhat larger samples of steel are taken for the McQuaid-Ehn carburizing test. These samples are also cut so their surfaces represent metal halfway from the edge to the center of the billet. They are carburized in the pots in regular production, being packed in among a load of gears, thus given the regular treatment in every respect.

Estimation of the grain size and the relative normality is made by comparing the microstructure of the specimen with a standard chart. Observation at 100 diameters gives the average grain size in the case, merging zone and core. A second examination at 400 diameters is more useful to check the normality, since the cementite network, its coagulation and the divorce of

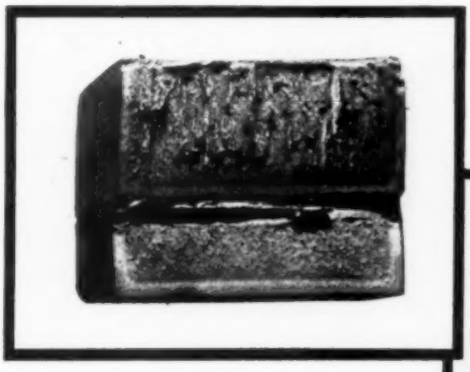
pearlite, as well as needles within the grains, are much more apparent at the higher power. Longitudinal sections of the metal are examined in this test to discover any banded condition in the ferrite in the core — a matter to which the 5% nickel steel is especially susceptible. Steels made in the electric furnace seem to be inherently fine grained and with some abnormal tendencies.

In passing, it is proper to remark that many of the requirements actually imposed upon the metal for gears have been worked out through the excellent cooperation afforded by the steel mills, by keeping the latters' metallurgists in constant touch with Brown-Lipe-Chapin Division's standards. This cooperation, extending over a period of years, results, in the case of the mills participating, in satisfactory materials being regularly produced with little trouble.

For instance, Fred C. Raab, the metallurgical engineer for Brown-Lipe-Chapin, became convinced many years ago that grain size, as determined by the microscope after carburizing and cooling slowly, had a definite influence on the facility with which steel could be machined and heat treated, and had prepared a set of standard microstructures for his guidance. Steel mills which have been able to control their practices so as to meet the purchase requirements over a period of years, have also been able to furnish steels reasonably uniform in grain size and normality to meet any changes, as the ideas and the gear cutting practice of the men at the Syracuse plant changed slightly. The present requirements in grain size are between four and six of the above-mentioned standard chart. Such changes have been made entirely as a matter of mutual understanding.

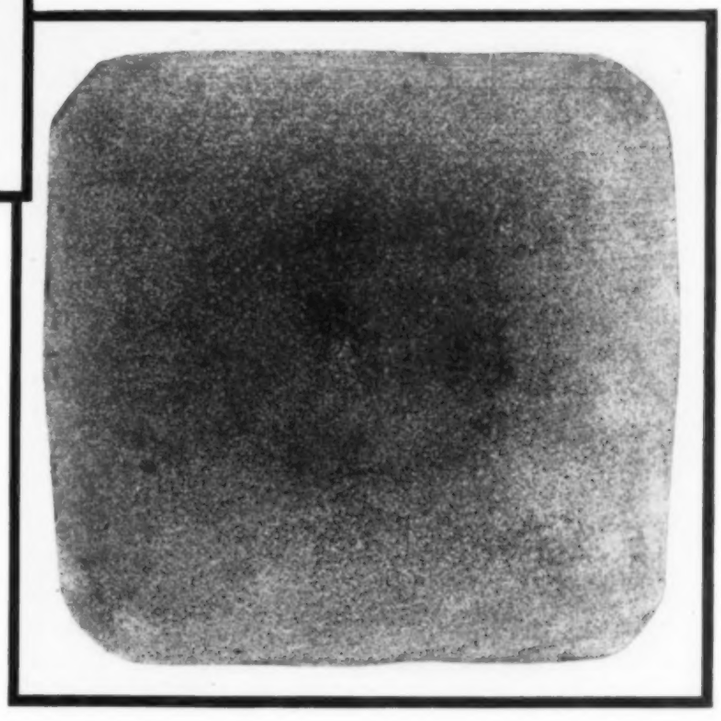
*Special Deep Etch Test.* In order to check up the conclusions of the microscopic examination for cleanliness, and also to coordinate with hardening tests next to be described, a complete disc from each sample from billet or bar is etched in boiling 25% hydrochloric acid. This is a different reagent from that mentioned in the Recommended Practices of the American Society for Steel Treating (National Metals Handbook, 1930 Edition, page 415), but its only apparent disadvantage is that it requires more time — three hours etching for the 3½% and 5% nickel steels.

Removed from the acid, the disc is scrubbed with a hand brush in running warm water, then dipped into a beaker of cold dilute nitric acid (approximately 5% strength). This cleans and brightens the surface. After a few minutes in this acid, the sample is again scrubbed vigorously in warm water, rinsed in alcohol and dried in an air blast.

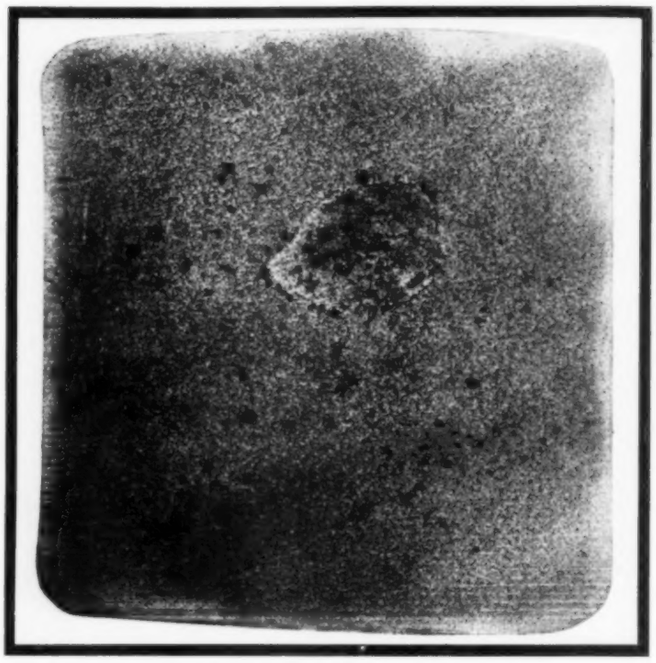


*At Left are Samples of Hardened Discs, One Woody and Rejected, the Other Fibrous and Accepted*

*Below Is an Acceptable Billet, Deep Etched.*



*At Right Is Shown a Very Bad Steel After Deep Etching*



As in the study for slag inclusions, the interpretation of the deep etch test is a matter of personal judgment on the part of the metallurgists at Brown-Lipe-Chapin. Aside from major defects, such as segregated centers and shatter cracks which reject a heat automatically, the appearance of the pickled surface gives indications to a skilled observer which vary by almost infinitesimal degrees, and which are to be interpreted in accordance with a knowledge of the characteristics of the type of steel under examination and in the light of the other tests — especially the following hardening test.

*Three Discs Hardened and Broken.* Half-inch discs, cut across the entire section of the billet, are then carburized and hardened in production routine, just as the type of steel would be treated in the form of a gear. For instance, the tests for a 3½% nickel steel will be as follows:

*(a)* Carburize in production, quench from the pot in oil.

*(b)* Carburize in production, quench from the pot in oil, reheat to 1380° F. and quench the disc in oil.

*(c)* Carburize in production, cool in the pot, reheat to 1475° F. and quench in oil.

In the first place, all these discs must be file hard over the entire surface. Each is then broken to give a longitudinal fracture (direction is important). The cores should be entirely fibrous, as shown in the specimen on page 93.

Coarseness in the core is related with the grain size and normality as indicated by the McQuaid-Ehn test. For instance, a very abnormal steel, fine grained before carburizing, does not form large crystals at the long carburizing heat, and the case will be fairly fine. In all carburizing steels used at Brown-Lipe-Chapin, heat treatment *(b)* gives a case softer and tougher than either *(a)* or *(c)*, but quenching from the pot is, of course, the more economical.

Another indication of this test is whether the structure shows a woody fracture. (This would be forecast by the deep etch test, and in severe cases, by the number and disposition of the slag inclusions.) Woody fracture is brought out best by heat treatment *(b)*, and represents material entirely unsuitable for quality gears.

These acceptance tests, in cumulative effect, might appear to set up conditions impossible for any steel company to fulfill regularly. But as a matter of fact, they all are designed to exhibit different aspects of good metal. If the steel has inherent quality, it will give a good account of itself in all of these examinations. Only when its excellence is a little in doubt, will anything adverse appear in the acceptance tests, and ordinarily a heat must be clearly deficient in more than one characteristic before it is rejected.

The quality of the gearing in the cars made by General Motors is well enough known to warrant the statement that these inspection tests guarantee material eminently suitable for the purpose to which it is put. The fact that two or three steel manufacturers are able to ship steel to the Brown-Lipe-Chapin Division regularly, and are classed as an "established source of supply", is an indication that careful manufacturing practice will produce steel (both carbon and alloy) which can regularly pass even these exacting requirements.

Recommended Practice Committee Release

# Outline of Welding . . and allied processes

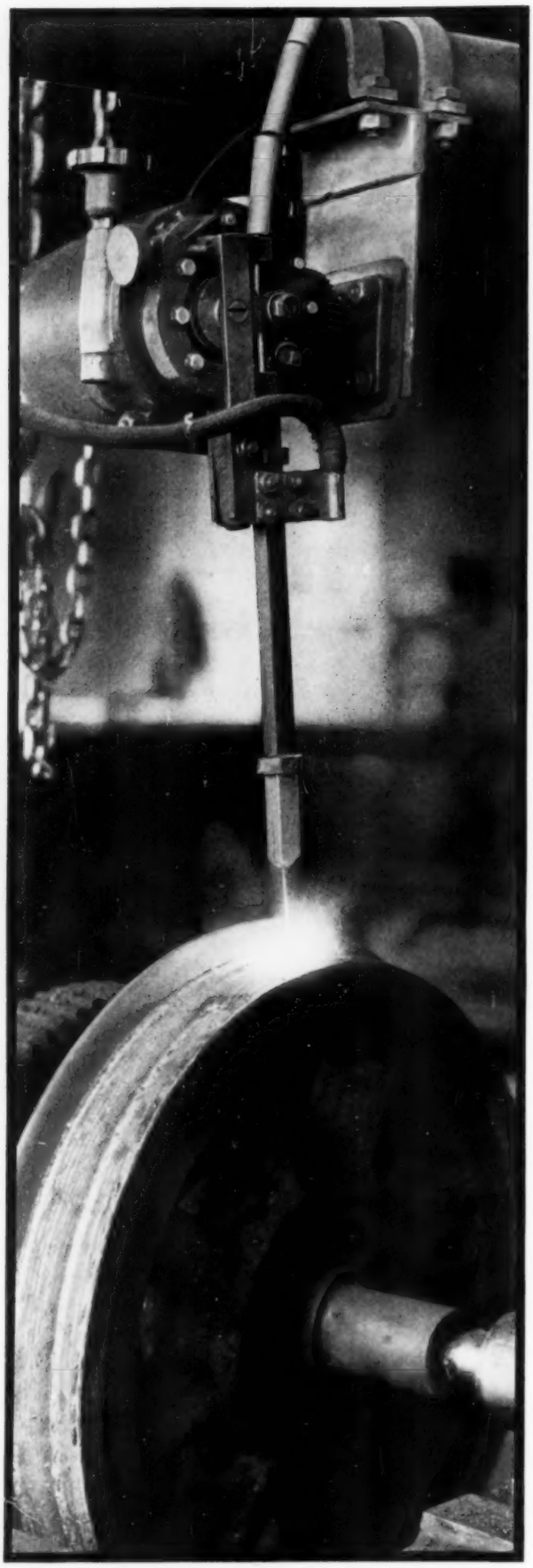
By F. T. Llewellyn

THIS OUTLINE of welding and its allied processes is as they exist in July, 1930. Special attention is paid to the characteristics and inter-relation of the newer processes. Description of the processes is supplemented by notes on the effect of heat treatment, methods of testing, physical properties and fields of use. Gas cutting methods are included in a section to be published next month. Questions of cost and matters of patent are not discussed. The attempt to classify the processes and their uses from the standpoint of function (chart on page 83) is believed to be original with the author. In other respects the information presented is drawn from various sources, notably the publications of the American Welding Society.

*Definition.* Welding may be briefly defined as a localized consolidation of metals by means of heat. While it is true that, as a laboratory experiment, the surfaces of certain metals can be united without heat, and that the several welding processes involve other factors in addition to heat, yet the importance of heat in all practical welding operations warrants its inclusion as a common factor in any useful definition. The welding processes proper are usually employed to unite like metals for the purpose of transmitting considerable stress. The definition includes subsidiary processes, such as brazing and soldering, in which unlike metals are employed, and whose product is not usually intended to transmit much stress. These subsidiary processes will not be described in further detail here.

*Surfaces.* It is both logical and convenient to consider the condition of the metal surfaces in the locality of the weld during the operation of welding as the first criterion in the classification of welding processes. The predominant condition of the metal at and adjacent to the surface may be either plastic or fluid. If plastic, the application of external pressure is necessary but no added material (weld metal) is required. As a result of pressure the parts to be welded (base metal) are reduced in length, width or thickness. If the surfaces are in fluid condition the addition of weld metal is necessary but no pressure is required. As a result of the added material the base metal parts are usually enlarged either in length, width or thickness.

The term fusion is popularly applied to



*"Weldomatic" Rebuilding Tire of Mine Locomotive Wheel, Mounted in Lathe Centers. Courtesy Westinghouse Electric and Manufacturing Company.*

those welding processes in which the surfaces are in fluid condition. The fluidity is essentially liquid in nature but there are indications of a partially gaseous state in the weld metal during some processes.

In both the plastic and the fusion processes the surfaces to be welded must be free from foreign matter, but the presence of ordinary mill scale is usually not harmful and in certain electric resistance processes it is advantageous. In all plastic processes the surfaces are brought into close contact, whereas in most of the fusion processes the provision of a narrow space between surfaces has the beneficial effect of relieving internal cooling stresses and also of permitting a more efficient weld.

The plastic zone of most metals ranges from melting point down to about 100° F. below melting. In a few metals, such as lead and cast iron, the plastic zone is so narrow that they are difficult to weld except by fusion. In the case of many metals (copper, brass, bronze, aluminum) oxidation begins at the temperatures needed to prepare the work, and the welding operation must therefore be either instantaneous or shielded.

*Source of Heat.* In the plastic processes heat is produced either by a forge furnace, by resistance at the base metal surfaces to electric current, or by a progressive chemical reaction (thermit). Strictly speaking, the combustion of fuel incident to the forge and gas processes is a chemical reaction, but it is convenient here to confine the term to special reactions such as accompany a thermit process.

In the fusion processes heat is produced either by the combustion of gases mixed in a gas torch, by an electric arc, or by a thermit chemical reaction. In many fusion processes a temperature several thousand degrees Fahrenheit higher than the melting point of steel occurs at certain points in the heating medium.

*Specific Processes.* The following description covers the more important processes. Their relation may be traced on the chart on page 83 wherein the trade name of each process is printed in heavy type. In some processes

*Bronze Welding in the Field a 36-In. Cast Iron Water Supply Pipe With an Oxy-Acetylene Blowpipe. Courtesy Linde Air Products Company.*

the characteristics overlap and the classification should therefore not be considered to apply with absolute rigor. Several of the more recent processes, while already brought to a point of commercial utility, must be viewed as still in a developmental stage. Goggles and other protective devices are required by workmen engaged in most of the newer processes, especially in the case of flash and fusion welding.

*Forge Welding.* This is by far the oldest process of welding, indeed it is the only one whose general practice antedates the twentieth century. The base metal parts are heated to a plastic condition in a coal, coke, oil or gas furnace and then united by means of pressure. In manual forge welding the pressure is applied at high velocity in the form of blows from a comparatively light sledge hammer. In mechanical hammer welding the blow is applied at lower velocity but the hammer may be as heavy as is convenient and its momentum may be augmented by steam, hydraulic or other pressure. In mechanical roll welding there is no sudden blow. The parts to be welded are forced longitudinally between rotating members whose bearings are rigid enough to transmit

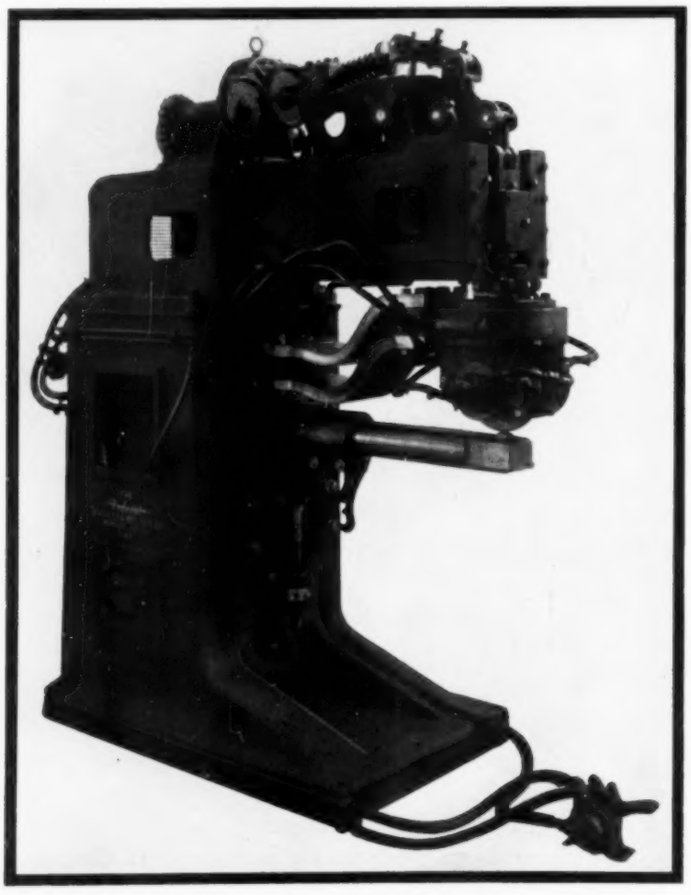
the pressure required for a perfect junction.

*Resistance Welding.* The electric resistance processes originated with an accidental discovery by Elihu Thompson in 1885. These processes require the localization of heavy current combined with great mechanical pressure. Alternating current is usually employed except on very small work. With equipment of the efficiency available at the present time the current and compression requirements (per square inch of area to be united) for the resistance welding of medium rolled steel are, respectively, 30 kva. for 10 sec. and not less than 5,000 nor more than 8,000 lb. The electric power required for other durations varies inversely as the time. The mechanical pressure required does not vary with the time, but it must be modified for different grades of base metal.

An important feature in all resistance processes is the composition of the electrode die which must possess good thermal and electric conductivity combined with great hardness and sufficient strength. A combination of these requirements has been achieved to a high degree by the use of a hard copper electrode faced with one of several alloys whose hardness at the welding temperature of the product is much greater than that of copper.

In the butt welding form of the resistance process pieces of the same cross-section are mechanically gripped and pressed together while heat is generated by passing a very large electric current through the area of contact. The original upset method is a form of butt welding in which high mechanical pressure is applied and maintained throughout the operation, the temperature being kept below melting. The extruded metal is upset into a roughly convex form which, if desired, may be molded to predetermined shape in a die, thus securing a kind of drop-forging, or it may be ground or cut off. Today the upset method is generally combined with flashing. The flash method as first developed is a form of butt welding in which, after initial contact and heating, there is a brief period during which the parts are slightly separated, thereby causing the current to create intense sparking. The weld is then completed under great pressure and with increased current at a temperature sufficient to melt a portion of the metal, part of which is extruded in the form of a thin burr which may be ground or cut off. This method is still followed on very large work, but on smaller work the flashing effect, which in the original process was secured by separation of the parts, is obtained by an automatic successive adjustment of currents and pressures, first to preheat the parts and then to flash them. There is no hesitation in the cycle and as a result this form of flash welding is quite rapid.

In the spot welding form of the resistance process two or more sheets of base metal are held between bluntly pointed metal electrode dies which pass a very large current at fairly low voltage through the sheets. Immediately following, and with current maintained, the



*Side View of Seam Welder for Sheet and Thin Plate. Courtesy Federal Machine & Welder Co.*

# SIMONDS STAINLESS

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electrodes are forced together with sufficient mechanical pressure to unite the surfaces of the sheets in a spot whose size is approximately that of the point of the dies, and this pressure is maintained until after the current has been cut off. Projection welding is a method of spot welding wherein small ridges, or other projections, are pre-formed by rolling or otherwise on one or both pieces of base metal. The projections serve to localize the current. In the manufacture of wire fabric, that is to say, where wires cross each other to form a mesh, the desired localization is provided naturally from the contour of the wires.

The seam welding form of the resistance process involves features allied to both butt and spot welding. Two or more sheets or bars of base metal are passed between electrode rollers, such as contained in the upper and lower horn of the machine shown on page 98, or between a succession of dies, which transmit the current and the mechanical pressure required to produce a welded seam, usually a series of closely welded stitches. A recent process for welding the longitudinal seams of steel tubing utilizes direct current by means of a homo-polar generator.

*Electropercussive Welding.* The percussive methods of resistance welding differ from butt or spot welding in that *(a)* a direct current supply is essential, *(b)* there is a sudden discharge of electrical energy at the junction in an arc which is extinguished by a percussive blow, and *(c)* the surfaces united are partially fluid. The energy may either be supplied by the discharge of a condenser (electro-static), or transformed by the collapse of a magnetic field (electromagnetic).

*Thermit Pressure Welding.* The thermit pressure process has also been called thermit pipe welding for the reason that at one time its largest use was to connect the ends of pipe, but it is now also employed in other important fields. The chemical reaction which generates the required heat will be described later in connection with the thermit process proper, in which the thermit acts both as heating and filling medium, whereas in the thermit pressure process it serves merely to generate enough heat to bring the abutting parts to the plastic stage.

In applying the process to pipe the pipe ends are cut square and faced, any threaded portions being removed, and they are then butted together by means of clamps actuated by longitudinal bolts. Light cast iron mold segments are placed so as to form a space around the butted pipe ends and into this space are poured the products of the thermit reaction, molten iron and molten alumina. The alumina enters the mold first and coats it and the pipe, thus protecting these parts from alloying with the superheated iron.

In a short time these two molten products bring the pipe ends to a welding temperature. This time varies from a few seconds to several minutes, depending on the size of the pipe. Welding pressure is then applied by giving the bolts one complete revolution. The clamps may be released immediately and the mold segments removed, when the thermit iron and the alumina fall away from the pipe and out of the mold segments, thereby permitting the mold to be used repeatedly. The pipe joint is slightly upset, its enlargement being on the outside only. When the process is employed on coils the pipe is usually welded before being bent.

*Gas Welding.* We now leave those processes in which external pressure is employed and come to the fusion processes in which the weld is produced in a fluid state by the addition of molten weld metal. In continental Europe

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the term autogenous is applied to any method of so doing, by means of gas or arc.

In the gas process the heat is supplied by a flame resulting from the combustion of compressed oxygen or air with compressed acetylene or other gases mixed in a torch so regulated as to produce a flame having certain desired characteristics. The first practical oxy-acetylene welding torch was devised in Paris in the year 1901 by Fouché and Picard. The construction of the various torches of commerce differs in detail, but in all designs the two gases are supplied through separate passages, their pressures are regulated independently, and they are thoroughly mixed prior to combustion. After mixing the gases are forced through a torch-tip, of size suited to the work in hand, at whose orifice combustion takes place in the form of an incandescent cone. If the mixture contains an excess of acetylene a carburizing flame results. If an excess of oxygen, an oxidizing flame results. If acetylene and oxygen are balanced, a neutral flame results. In almost all gas welding operations the maintenance of a neutral flame is required, but in the welding of certain alloys such as aluminum a slightly carburizing flame is permissible. For some purposes hydrogen is advantageously substituted for acetylene in the welding of aluminum. An oxidizing flame must be avoided.

The weld metal is usually supplied independently in the form of single pieces of welding rod whose size, composition and coating (flux), if any, vary with the work to be done. In the union of thin sheets the weld metal may be taken from surplus base metal.

In manual gas welding the operator holds the torch in one hand so that the tip of the incandescent cone almost touches the base metal, while with the other hand he maintains the end of the welding rod near to the work. He oscillates the flame over the base metal, first slightly ahead of and then at the weld, so as to melt it into a puddle. The rod is melted solely by heat radiated from the flame and puddle, and in melting it adds to the volume of the puddle. When the molten metal deposited in the puddle attains sufficient volume both flame and rod are moved progressively forward (or backward) thus permitting the deposit to solidify


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It is the work of the Bell Telephone System to enable friends, families and business associates to speak clearly and immediately with one another, wherever they may be. Its service is as helpful and accessible on a village street as in the largest cities.

To match the growing sweep and complexity of life in this country, to prepare the way for new accomplishments, the Bell System is constantly adding to its equipment and bettering its service.

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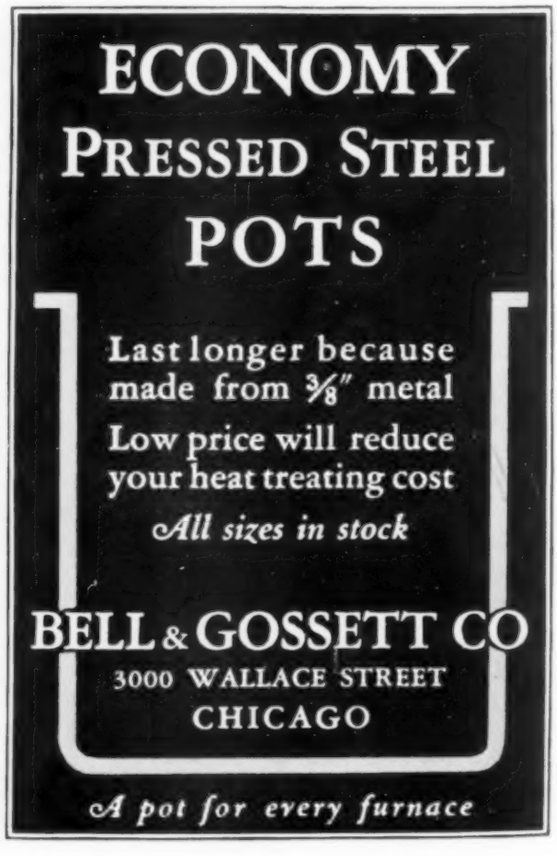
as an integral portion of the base metal parts.

Machines that are automatic except as to the maintenance of a neutral flame are being increasingly employed in gas welding, but as yet industrial applications of the process are mostly manual. Welds may be made in either flat, vertical or overhead position.

The shape and size of the deposited weld metal vary with the work to be done. In making butt joints, which are a type to which the gas process is pre-eminently suited, prior to the welding operation the edges of the base metal are usually bevelled, a narrow shoulder being left square, so that after assembly they take the form of a single or double Vee slightly separated at the root, and the space thus provided is filled by the weld metal. For most purposes the open side of the Vee, and if practicable the root also, is reinforced by the convex protrusion of weld metal somewhat beyond the surface of the base metal.

The process is also used to make lap and other types of joint. In a lap joint the weld takes the form of a triangle (fillet) whose cross section lies outside the planes of the base metal and whose hypotenuse is usually reinforced. In all gas welds the entire cross section of weld metal may be deposited at one time; in thick welds the deposit is laid in sloping formation.

For many purposes the base metal is preheated before being gas welded. The preheating may be done with a torch in which gases cheaper than compressed oxygen and acetylene are used; the work may be surrounded by a charcoal fire, or it may be placed in a furnace. Preheating has several advantages. It reduces any tendency of the welding operation to cause subsequent cooling strains. It decreases the consumption of the more expensive gases, oxygen and acetylene, and when done in a furnace it saves the operator's time. It also improves the quality of the joint by releasing such internal stresses as may already exist in the base metal. The duration of the gas process causes the heat generated at the weld to extend back over a considerable area, and this makes preheating very desirable in the welding of materials having low ductility.



The above Q-Alloy K A2 casting is 20" long and from ⅛ to 3-16" thick. The design is by Oscar Bach, noted metal craftsman of New York, and is the radiator grill in the office of Walter P. Chrysler in the new Chrysler Building. Moses, Jr., pictured in the center, is in a helluva fix. If he backs up that thar wheel he will break his toe. If it rolls ahead he'll sever digits. What would you do?

# "STAINLESS STEEL" "RUSTLESS IRON" CASTINGS

## DON'T PUT ANY SALT ON THAT TALE!

There is much confusion in the high iron cast alloy field over the names "stainless" *and "rustless", which have been impressed on the public mind and mean about as much as the slogan "one man top" did in the automobile industry. I am speaking of cast alloys, none of which in the higher iron variety are rustless unless highly polished and then only after they have had a couple of pickles.

There seems to be a reasonable amount known in connection with the rolling and fabrication of such alloys, while the cast end of the game has been quite thoroughly neglected with the exception of a few enterprising souls who have gone it alone. At the present time there are some thirty steel foundries making or trying to make what they think is .10 or under carbon, 18 chrome, 8 nickel type of materials. What they are getting is most amusing, both from the standpoint of analysis, appearance and utility in service. This epidemic of manufacturers in a new field, grossly ignorant of the manufacture of complex alloys and ill equipped to either make them properly or sell them intelligently, is going to set back the cast chrome nickel alloy business at least two years. While these makers are learning something about the business there will be much money lost and much harm done.

The chrome and chrome nickel alloys are well established in sheet form. There is a wide field for the castings as these are excellent for many applications. Such alloys, some of which we have been making for years, others with which we have had more recent experience, are in no sense cure-alls. They serve many fields for which high nickel chromium alloys are unsuited. There is a grave danger of their being sold and recommended for high temperature uses beyond their range.

As an exclusive manufacturer of complex alloys looking down on these "new" materials from experience with more complex and more costly alloys we are in a totally different position from the steel foundry looking up to them as a mystery of modern science.

This company is licensed under Chemical Foundation and Krupp-Nirosta patents and will welcome an opportunity to work with any user of these high iron alloys in conducting tests and seeking the proper applications for their many excellent qualities in the corrosion resistance field. H. H. H.

*A registered trade name misapplied to many "corrosion resisting" utensils that do rust in cast form.

### HE SAW—AND ACTED

From a newspaper advertisement I gather the following facts, which are boiled down a bit because of space limitations:

In 1863 a man named Frederick Walton stood looking at the thick film that had formed on a can of paint, as will happen when paint is exposed for any time. He pried the film off and examined it. It was tough, elastic, smooth; it had an even color, and further experiment proved that it was durable.

Walton knew what the film was. It was linseed oil that had oxidized and turned from a liquid to a semi-solid, elastic material. He mixed some of it with powdered cork. Then he took a strip of strong, tough burlap and pressed the composition into the mesh of the burlap. And he named it Linoleum.

Great mills in America, Europe and the British Isles annually produce millions of yards of linoleum. And all because one man *thought about what he saw.*

Most of us see many things—and think about very few things. Every progressive step the world has known can be traced to some man's vision, created by thought.

I sometimes wonder if it wouldn't pay us, in the mad whirl that we call Life, to slow up a bit, observe more carefully and then think our way through our problems and our opportunities.

---

"Say Bill, if you had five bucks in your pocket, what would you think."

Bill: "I'd think I had somebody else's pants on."

—*John W. Hall's Bulletin.*

---

### THE EXPERT

The only permanent thing on this old earth of yours and mine is change. The only man who deserves to be called an expert is he who learns all there is to learn about his specialty and then keeps an open mind ready to unlearn and to adopt better methods.

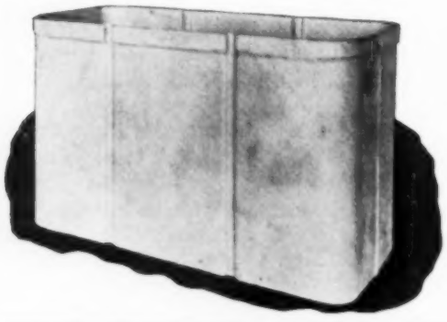
*(Continued on page 6)*

# Carburizing Containers...

THE largest carburizing container installations in America, some of them totaling well over half a million dollars each, are the best evidence of Q-Alloys' success, for the reward of the manufacturer is the repeat order. These large users have experimented with different alloys for a number of years, have tremendous resources, large heat treats, and every experimental facility. You can learn from them.

We will be glad to supply customer references to any legitimate prospect writing on his letterhead.

While the cheapest carburizing boxes available are only approximately 40% lower in price than Q-Alloys some users want to buy reliable lower grade materials. We supply carburizing containers in 60 nickel 12 chrome and in 35 nickel 15 chrome, grades B and C respectively, at the same prices as charged by other manufacturers of alloys of similar analysis. The buyer gets added benefit of the superior raw materials, better foundry practice and engineering service associated with Q-Alloys.



The reason for this is that nickel chrome carburizing boxes are produced by us under patent No. 1,270,519 and that uniform prices are established by the licensor. This applies to cast or sheet boxes. Possibly you have not purchased General Alloys carburizing containers in the past because we did not have the lower grades available. We welcome your inquiry.

# CHEATING WHO....?

Once upon a time a man walked in his sleep, stole his own watch and hid it in the stove. A hot time was had by all.

The gentleman above mentioned must have felt very much like a very good furnace manufacturer who contracted to supply Q-Alloys and who in an original strain of economics sold a furnace with three different alloys in it, none of them made by us. One was a competitive product of fair repute, the second the product of a prospective alloy maker cutting his "I" teeth on the furnace builder, the third an elastic alloy. The whole works went haywire P.D.Q., if not sooner.

Our representative in the furnace buyer's territory, having no knowledge of the furnace, dropped in to sell alloy. The irate buyer who thought he had Q-Alloys in the furnace climbed aboard our representative for a busy half hour. We think the furnace builder has a busy half hour ahead also, which may arrive before he sees this in print.

ALLOYS PROGRESS PAGE VI

# S·P·R·A·Y

CONTINUED

Integrity in business means a trade as good for one party as the other. —*Nations Business.*

Money will buy a mighty good dog, but it won't buy the wag of his tail. —*Anne Keil.*

SAD STORY

The saddest story of the month was about the too-observant fellow who remarked to his girl—"Your stockings seem rather wrinkled, dearest."

"You brute," exclaimed the girl, "I have no stockings on."

—*Mead Co-operation.*

A carload of alloy chain, born into an unkind world.

It had its picture in the magazines and then went forth to the steel mill furnace. It is now returning to its maker, freight C. O. D.

Maybe the chain was all right and the load was wrong, or the furnace got too hot. We'll not sit in judgment. All parties concerned, however, know that General Alloys engineers looked over the job and said that it wouldn't work, offered our design experience. There's a distinction between engineering and selling alloy.

OH YEAH?

"Ah wins."
"What yuh got?"
"Three aces."
"No yuh don't. Ah wins."
"What yuh got?"
"Two nines an' a razor."
"Yuh shoh do. How come yuh so lucky?" —*Splinters.*

The other day he slapped me on the back and said:

"Why, you don't look any different than you did ten or fifteen years ago. How do you keep from growing old?"

And I said to him:

"By thinking young thoughts—by refusing to bother about the passing years, and by continuing to reach out for new ideas and experiences."

And that's the truth.

It seems to me that men—and women, too—begin to age first in their *minds.*

"Is that a lion or lioness, papa?"
"Which one, dear?"
"The one with its face scratched and the hair off its head."
"That must be the lion."
—*Dublin Sunday Independent.*

If you want your dreams to come true, don't oversleep.

—*Yale Panel.*

# Scrap Value $10 per lb.

Mr. H. H. Harris,
General Alloys Co.,
Champaign, Illinois.

Dear Hank:

When you sold me that Q-Alloy Salt bath Pot you said it would cost me one dollar per pound and have a twenty cent per pound scrap value. You were all wrong. It cost me a black eye and a thousand dollars, and its scrap value is at at least ten dollars a pound. Here's my mathematics and you can have Mac and all his engineers check my safety factors.

It was like this: We had a swell new furnace designed to heat a salt bath for annealing a thousand pounds of steel each hour of the twenty-four hours of the day. The Pot was of welded steel, forty inches deep, and forty inches in diameter, and held about two tons of molten salt. Every few days the pot would burn through, and we'd have a flood of molten salt; and four days later the brick masons would have what was left of the furnace ready to fire up again Hank, it just made me cry to see that furnace get ruined every so often, so I started to figure that maybe one of your fancy dollar-a-pound alloy pots might not cost as much in the long run as the hundred dollar steel pot and a new furnace lining each time, plus a shut-down. So I started to explain to the Superintendent that by paying $1039 for a Q-Alloy pot—but right there is where I got the black eye, because he started to explain to me just what he thought of college graduates who thought it was a swell idea to spend $1039 for a hundred dollar pot. I've got to admit that his explanation was forceful, and hit me right between the eyes.

But we got the pot.....and it worked out just as Mac and your engineers had figured it.

Hank, from that day henceforth the Superintendent and all the "Old Timers" were a bunch of lambs. No more scraps, no more "get-the-cheapest"—just all pepped up to try any miracle I might figure out in my own little college way. Don't you think it's worth at least $10,000 to get that spirit into a plant? Well, ten thousand dollars divided by one thousand pounds of Q-Alloy is ten dollars per pound, which is how I figured its value from the scrap standpoint.

By the way, Hank, that little incident helped put the oriental rug in the new private office with my name on the door.

I still think Q-Alloys are fine.

Hoping you are the same,

SALT MAN SAM

P. S. THE part about the black eye is extra. It was just a bright idea that struck me—not the Superintendent. S.M.S.

---

Ed. note: The above letter and information came voluntarily to us on Nov. 3rd from a well known executive of a first-rate concern. At his request we are not mentioning his name but will submit documentary proof through the A. S. S. T. to any reader doubting the source. We did not write this or have any knowledge of or part in the preparation of it.

## THIS IS THE THOUSAND DOLLAR POT... THE FACTS

A Q-Alloy pot was installed in this leading industrial plant through the efforts of a young metallurgical engineer who had a tough time convincing the "old timers" that they could spend money to save money by buying quality equipment.

The $1000 pot did its stuff and backed up the judgment of the young metallurgist, incidentally saving the concern a considerable amount of money.

We say "incidentally" because the saving of $1000 or so in pot cost, breakdowns, etc., was only the direct result on the cash register. The indirect results began to pay added dividends that have been constantly increasing.

## THE MORAL

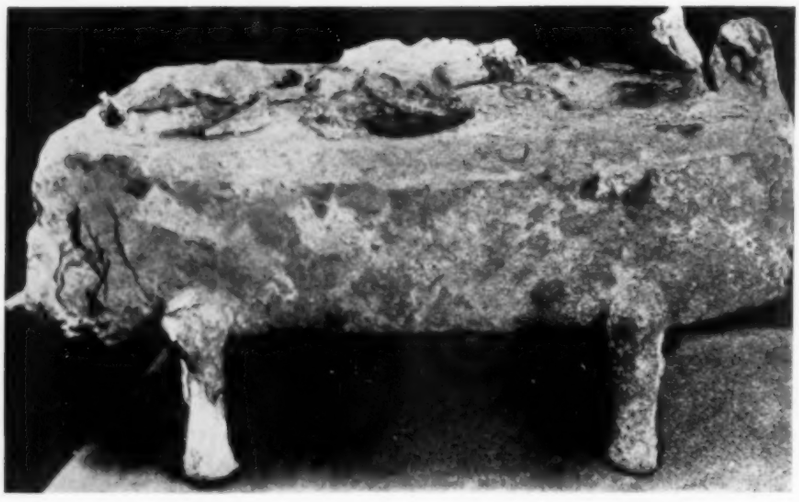
The moral of this story is the victory of logic over habit, of intelligence over precedent. That plant has had many thousands spent in new equipment and has been completely revamped in several departments because the initial inertia of the preachings of precedent were broken down by the teachings of today.

No fooling about that oriental rug.

There are lots of plants well rooted in the past that could take a leaf out of Sam's book to advantage. How about the malleable industry with its hundreds of thousands wasted in embryo sash weights diverted into annealing pots. How about the steel industry—we can't take space for that now. How about you and I? Let's break a couple of shackles.

# Two Hundred Years Before Christ

On the right we have what is believed to be the first cast iron stove in existence, dating back before 200 B. C. It is fired at one end has places for five utensils and a chimney. This stove was recently discovered in China and now reposes in a museum. The photo is by courtesy of A. P. Photo and Chicago Tribune.

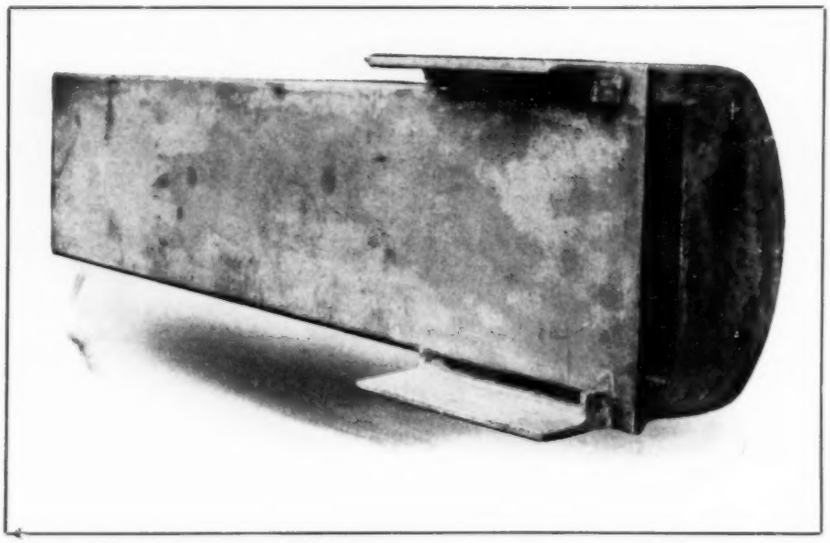


Evolution, invention, civilization, possibly science and certainly politics travel in cycles or circles, or both. When they were digging up this stove in China several were being installed in Detroit made of Q-Alloy along the same general idea.

"Damned clever, these Chinese," a slang phrase, is a grudging acknowledgement of Chinese scientific contributions. Wun Lung Ho got tired of looking at a pile of brick, then and now called a furnace, and said "Me fixee damn quickee." Twenty-two centuries later General Alloys engineers working with a Detroit brass producer hit on a similar idea and carried it out as shown in the Q-Alloy furnace below, complete in one piece all but burners and foundation.

The Chinese stove undoubtedly surprised the scientists scratching in the earth for knowledge. Some day archaeologists will be digging around Detroit, Mich., Fort Wayne, Ind., and Milwaukee, Wis., and will uncover a lot of queer looking gadgets.

"Who in the heck was this General Alloys," one remarks. "Just a high guy in the Q-Alloy dynasty of the flip and flapper age," remarks his companion. "They had a lot of funny looking stills in that era."



Damned
clever,
these
Chinese
!

ALLOY PROGRESS PAGE VIII

THERE is no fireclay bond used in the building of Carbofrax, Carborundum Brand Silicon Carbide Hearths—

¶No bond that will boil out and leave a "tacky" working surface.

¶"Carbofrax" always presents a dense, hard surface. There is no softening even under extremely high temperatures. Of course this means better working and furnace conditions—higher quality of heat-treated products.

¶Remember, too, that "Carbofrax" has a remarkably high heat conductivity—a greater resistance to abrasion and oxidation—greater mechanical strength.

¶You couldn't ask more of a refractory hearth.

"CARBOFRAX" HEARTHS

REG. U. S. PAT. OFF.

*Made of Carborundum Brand Silicon Carbide*

The CARBORUNDUM Company, Perth Amboy, N. J.

REG. U. S. PAT. OFF.

Christy Firebrick Company, St. Louis, Mo. Harrison & Company, Salt Lake City, Utah
Pacific Abrasive Supply Co., Los Angeles-San Francisco Denver Fireclay Co., El Paso, Texas
Williams and Wilson, Ltd., Montreal-Toronto, Canada

(CARBORUNDUM AND CARBOFRAX ARE REGISTERED TRADE MARKS OF THE CARBORUNDUM COMPANY)

# Reviews of Recent Patents

by Nelson Littell

Patent Attorney 475 Fifth Avenue, New York Member of A.S.S.T.

**Alloy Steel,** *by J. A. Succop, assignor to Heppenstall Company, of Pittsburgh. 1,775,615; Sept. 9.*

This invention relates to alloy steels and articles made therefrom, especially for the production of such edged articles as razor blades having high ductility, high hardness, and capable of withstanding rapid edge destruction. The alloy has a martensitic structure and consists of about .5 to 2 per cent carbon, 5 to 20 per cent chromium, .1 to 1.75 per cent manganese, .1 to 2 per cent molybdenum, .25 to 3.5 per cent nickel, .1 to 2 per cent of silicon, and .05 to 1.5 per cent vanadium, the remainder being iron. Blades made from this alloy retain their edge twice as long as those made from the best razor steel and eight times longer than those made from the best quality commercial steel.

**Pickling Composition,** *by H. J. John, assignor, by mesne assignments, to N. A. Emery, of Youngstown, Ohio. 1,776,858; Sept. 30.*

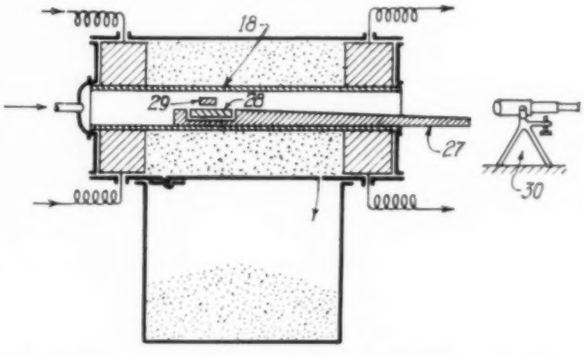
This invention relates to pickling processes for removing scale on steels. Its principal object is to reduce the time of pickling and to make it cheaper and safer. The pickling may be expedited by increasing the temperature and strength of the acid solution. In treating low carbon, copper-nickel steel, hydrochloric and nitric acids are used, and to this is added about 2 per cent to 5 per cent of rock salt. Palladium sponge, having an affinity for hydrogen, is also introduced to absorb the hydrogen bubbles. The palladium used is approximately one pound for each 2,000 gal. of the bath. The palladium may be removed and heated to burn out the hydrogen and again used.

**Hard Metallic Composition,** *by R. L. Adams, assignor to General Electric Co. of Schenectady. 1,775,014; Sept. 2.*

This invention relates to hard metallic compositions and to an improved method of making them. The process introduces a drying mixture of carbon and tungsten oxide into an aqueous solution of cobalt acetate, heats the mixture in air to decompose the cobalt acetate, fires the mass so obtained in a reducing atmosphere, and presses and sinters the fired mass.

**Carbide Melting Furnace,** *by Hermann Voigtlander and Otto Kaufels, assignors to Gewerkschaft Wallram Abteilung Metallwerke, of Essen, Germany. 1,776,053; Sept. 16.*

This apparatus is particularly adapted for casting carbides of metals such as tungsten, uranium, molybdenum and others hard to melt.




The furnace has a carbon tube resistance chamber *18* and graphite rods *27* in which the melting mold *28* is formed. The rod *27* is tapered for continuous inspection by the pyrometer *30*, which is focused on the check block *29*. By this construction it is possible to empty the mold quickly, and by using several graphite rods it is possible to work with great rapidity. The furnace may be electrically heated in any well known manner.

**Copper Alloy,** *by A. G. Krans, of Los Angeles, assignor of one-half to John S. Kirstein, of Los Angeles. 1,776,948; Sept. 30.*

This invention relates to copper alloys and describes a product having a greater tensile strength than steel which exactly matches the color of gold and does not tarnish or oxidize enough to destroy its brightness. The alloy contains approximately ½ to 1 per cent tin, 1 per cent nickel, approximately 5 per cent aluminum,

*(Continued on page 152)*

# QUENCHING SPEED . . .

R-1 QUENCHING OIL carries steel through its critical range 50% to 100% *faster* than the usual quenching oils.

R-1 QUENCHING OIL carries steel through lower temperatures *more slowly* than the usual quenching oils.

RESULT: Greater hardness *and* greater toughness.

WRITE FOR INFORMATION AND BOOKLET

**RODMAN CHEMICAL COMPANY**

VERONA · PENNSYLVANIA

from approximately $\frac{1}{10}$ of 1 per cent to 1 per cent beryllium and the rest copper. This alloy is suitable for use as cutlery and jewelry and may be varied to imitate closely various gold tone colors.

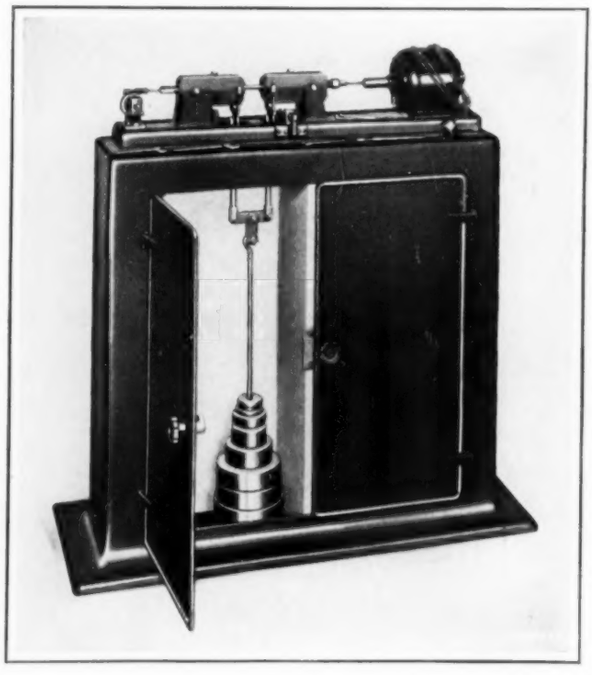
**Deoxidizer,** *by H. A. De Fries, assignor to Ludlum Steel Company, of Watervliet, N. Y. 1,775,339; Sept. 9.*

This invention relates to the manufacture of iron and steel and discloses an improved method of reducing the oxidation in the remelting of chromium and silicon alloys, whereby scrap steels and irons of such composition may now be advantageously utilized in the manufacture of ferrous alloys. Heretofore aluminum has been commonly used as a deoxidizer, but the oxide thus formed is objectionable as the aluminum and alumina sometimes get into the steel. In this patent the intermetallic compound $FeAl_3$ is preferably used, and as it is heavier than aluminum and has a much higher melting point it may be conveniently added in masses of any size desired. The $FeAl_3$ operates more slowly than aluminum and it is therefore necessary to hold the heat until the iron is completely deoxidized.

**Welding Machine,** *by H. S. Holmes and Le Roy H. Hoeffer, assignors, by mesne assignments, to Metropolitan Engineering Co. of New York. 1,776,587; Sept. 23.*

This patent discloses a welding machine for butt welding sheets by the Murray process. The machine is adapted for currents of extremely high ampere strength in proportion to the cross section, current being applied for a very brief regulated period of time, while the parts are pressed together. The method consists in pressing two pieces of metal in contact together, passing an electric current through the joint. The apparatus includes a mechanism to apply electro-magnetic force directly and with undiminished speed to move the work pieces toward each other, and insulated anti-friction bearings for the moving parts to facilitate the take-up of the work.

*(Continued on page 154)*

THE R. R. MOORE
FATIGUE TESTING MACHINE

•

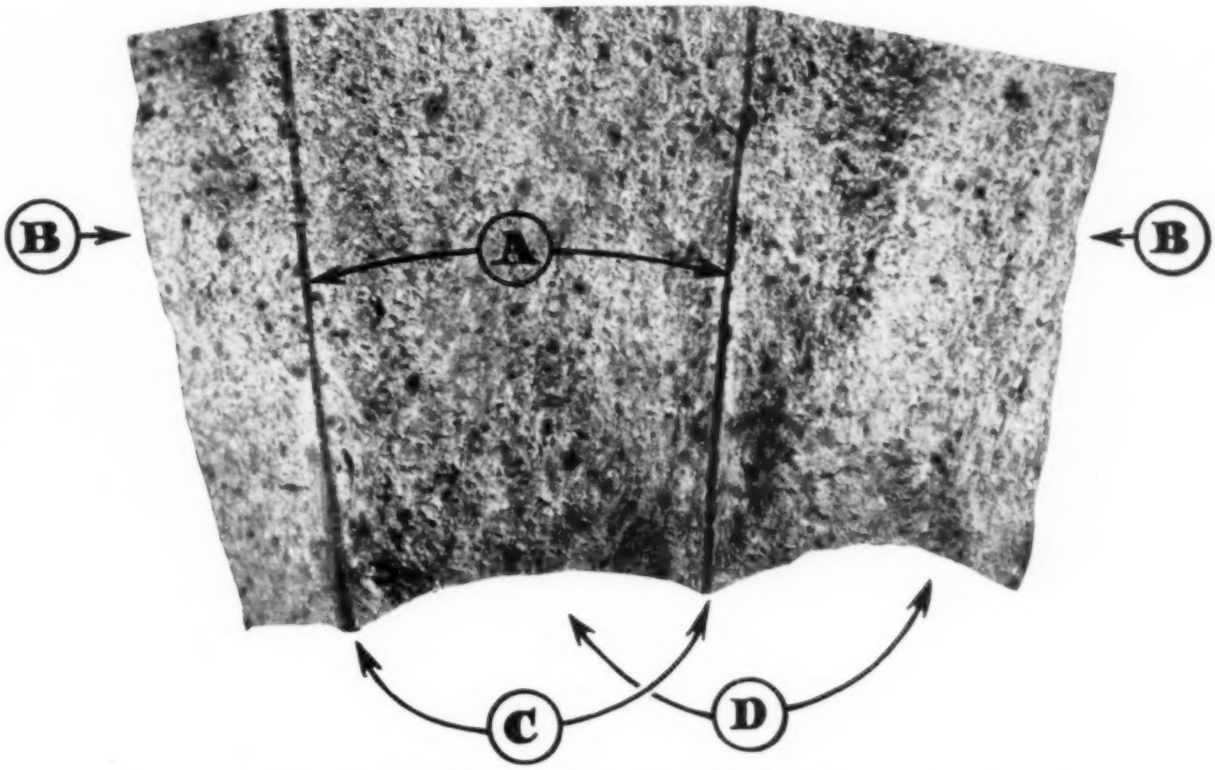
A thoroughly practical and reliable machine for determining the life of metals. Adaptable to various shapes and sizes of specimens. • It has proven its value in the laboratories of scores of industrial corporations, government departments and universities.

WRITE FOR OUR PAMPHLET ON FATIGUE TESTING

THE THOMPSON GRINDER COMPANY
1534 WEST MAIN STREET •• SPRINGFIELD, OHIO

# How are Your Arches holding up?

**Compare the next ARCH that falls or is torn out, with section illustrated below . . . . *this ARCH was laid in KROMEPATCH.***




**A** Thin even KROMEPATCH joints bond brick into a monolithic structure. Note absence of crumbling, fluxing, bubbling and squeezing out of KROMEPATCH.

**B** In tearing out this section, the brick broke while KROMEPATCH joints remained intact. The joints are stronger than the brick.

**C** KROMEPATCH protects brick by resisting destructive elements, preventing penetration at joints. Note how joints project, proving conclusively that KROMEPATCH is more resistant to abrasion and destruction than brick themselves.

**D** Brick wear back in center (concave) while strong KROMEPATCH joints project, giving protection where it is most needed and thus increasing service life of arch.

**REMEMBER:** Joint failure is caused by either crumbling or melting of bonding material.

Crumbling joints (material that lacks bond) allow heat to penetrate, exposing corners of brick which crack and fall out. This action repeats itself and soon joints are wide open and you need a new arch . . . Joints made of clay base cements (lacking refractoriness) soften at low temperatures and flux sides of brick. Bonding material and fluxed brick bubbles from joint allowing heat to penetrate. Result . . . joint deeply cut out and short arch life.

KROMEPATCH Cement is primarily chrome ore . . . does not crumble, squeeze out or flux brick. Use it and avoid short ARCH and refractory lining life.

**KROMEPATCH**

***does prolong the service life of furnace linings***

E. J. LAVINO AND COMPANY

REFRACTORIES DIVISION

CHROME, MAGNESITE AND SILICA REFRACTORIES

BULLITT BUILDING PHILADELPHIA

*"Pioneers in Chrome Refractories"*

"DISTRIBUTORS IN PRINCIPAL CITIES"

## Patents

**Spring Forming and Hardening Device,** *by Adolph D. Bach, of Newtonville, Mass. 1,763,610; June 10.*

This invention relates to machines adapted to form an elongated strip of malleable metal into a circular or oval form and hold it in such position during the hardening process, which process enters into the manufacture of certain types of springs. The machine comprises a rotatable table whose periphery is shaped to correspond with the spring to be formed, with means on the periphery for engaging the entering end of the strip, means for rotating the table, a roller spring pressed toward the periphery of the table to bend the strip thereabout, a depressible stop at the rear end of the strip, automatic means to depress said stop while the strip is being bent, and means to bring the stop into operative position to hold the strip after forming. The machine is claimed to be simple, cheap, and efficient in the performance of the bending and supporting.

**Die Casting Alloy,** *by Charles Pack, of Brooklyn, and Joseph C. Fox, of Toledo, Ohio, assignors to Doehler Die Casting Co. 1,764,011; June 24.*

This invention relates particularly to zinc base alloys having means for retarding the aging thereof. Such alloys are especially used in the production of castings in metal molds or dies, and zinc alone solidifies from the molten state in relatively large crystals and makes unsatisfactory castings. The addition of other metals has frequently caused undesirable phenomena known as aging, and in the present invention an improved alloy is made by the inclusion of lithium to this combination of elements. Other metals may also be added for the production of other valuable properties, such as copper, nickel, and other metals. The addition of the lithium apparently prevents swelling or aging and the improved alloy has a zinc base comprising zinc in excess of 75 per cent, aluminum within the range of 1 to 15 per cent, copper within the range of 1 to 10 per cent, and lithium less than 5 per cent.


FOR ALLOY STEEL CASTINGS

made to your Analyses and Heat Treated to your Specifications:

—consult—

WRITE FOR W ALLOY BULLETIN

WEHR STEEL COMPANY

MILWAUKEE, WISCONSIN

# High Chromium Steels

## *assure permanent youth to the*

## world's tallest buildings

Alloy Steel containing a high percentage of chromium was selected for the major portions of the exterior metal trim on both the Chrysler and Empire State Buildings. Selection of this metal clearly indicates its superiority for maintaining its original characteristics with no possibility of deterioration or other change.

Chromium is the element that provides the stainless and rustless properties of this metal; that assures its resistance to oxidation and atmospheric corrosion; that permits its preserving its full luster and original color for a lifetime without maintenance.

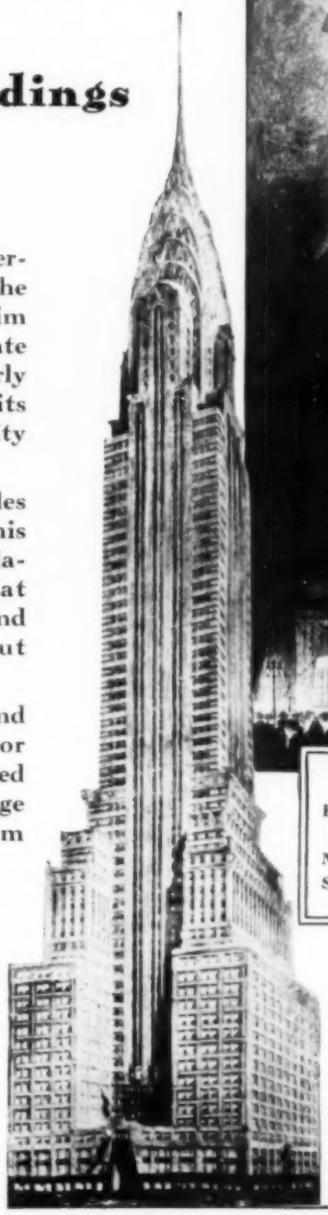
The growing demand for permanency, and the decided trend toward the superior physical and chemical properties imparted by a high percentage of chromium, urge a thorough investigation of high-chromium Alloy Steels. Electromet Engineers will gladly explain how this superior, exterior and interior decorative metal may be produced by the proper use of Ferro-Alloys. Write today.

**ELECTRO METALLURGICAL SALES CORP.**

*Unit of Union Carbide* UCC *and Carbon Corporation*

Carbide and Carbon Building,
30 E. 42nd St., New York, N. Y.

*The World's Tallest Structure*
EMPIRE STATE BUILDING, New York
Shreve, Lamb & Harmon, *Architects*
Meyer, Strong & Jones, Inc., *Engineers*
Starrett Bros. & Eken, Inc., *Contractors*



**THE CHRYSLER BUILDING**
William Van Alen, *Architect*
This majestic structure rises above Lexington Avenue at 42nd Street, New York. Its beautifully designed tower affords a splendid view of Manhattan and environs within a radius of many miles.

# Electromet
## Ferro-Alloys & Metals

## Helpful Literature Continued.

other low temperature applications. Ask for bulletin No. A-3.

**Steel Refining**—Densite Corp. of America. A folder in the form of a chart showing physical properties and photomicrographs of structures and inclusions of various carbon steels refined with Densite. Chart is of especial interest to metallurgists and heat treaters. Ask for bulletin No. A-5.

**Gas Heat**—American Gas Association. A text-book on the uses of gas in industry, giving comprehensive data on industrial gas heat. Illustrated. Free. Ask for bulletin No. A-7.

**Steel Handbook**—Jos. T. Ryerson & Sons, Inc. Handbook on Tool and Alloy Steels. Description, technical data and general information on tool and alloy steels. Also nontechnical description of heat treating methods and shop practice applying to various steels. Ask for bulletin No. A-8.

**Induction Furnaces**—Ajax Electrothermic Corp. This bulletin gives latest information regarding coreless induction furnaces in capacities up to several tons, and motor-generator equipments for energizing the furnaces. Ask for bulletin No. A-9.

**Corrosion Prevention** — Dearborn Chemical Co. Booklet describing latest scientific methods of treating water for prevention of scale, corrosion and foaming in steam boilers, dealing with related problems in connection with scale and corrosion in other power plant equipment. Ask for bulletin No. A-10.

**Heat Resisting Steels**—Midvale Co. Booklet is largely a diagramatic classification showing the content of the various alloys. It was produced because of a large number of requests for exactly this type of information. Ask for bulletin No. A-11.

**Tool Steel Handbook**—Columbia Tool Steel Co. Booklet contains valuable information concerning the making of tools, heat treating, application of steels, with tables, etc., gratis. Ask for bulletin No. A-13.

**Heat Resisting Alloys**—General Alloys Co. General catalog on Q-Alloys, which has recently been prepared describing many applications of heat resisting alloys. Ask for bulletin No. A-15.

**Pickling Equipment**—Weaver Bros. Co. Catalog listing equipment and supplies now available. Depicts all necessary equipment and has new "theory and practice of pickling." Ask for bulletin No. A-17.

**Stainless Irons**—Republic Steel Corp. Series of booklets descriptive of Enduro Stainless Irons. Each booklet is devoted to a single type of stainless and contains complete fabrication data, and descriptions of the physical and chemical properties. Ask for bulletin No. A-19.

**Electric Furnaces**—American Electric Furnace Co. A new four-page bulletin fully describing small electric box type furnaces. Ask for bulletin No. B-21.

**Alloys, Heat-Resisting**—Driver-Harris Co. A brochure illustrating interesting Nichrome installations. Nichrome is the original heat-resisting casting. Ask for bulletin D-1.

**Testing Machines**—Steel City Testing Laboratory. Bulletin describing Brinell, tensile and sheet metal testing machines. Ask for bulletin D-2.

**Electric Furnaces**—C. I. Hayes Co. "The Hayes Certain-Curtain Electric Furnace" new catalog on production furnaces for high speed tools. An exclusive, patented atmosphere control entirely prevents scaling, pitting and burning of the work. Catalog D-3.

**Preparation of Metallographic Specimens**—E. Leitz. This publication on grinding, polishing and etching will prove very interesting and instructive since it is a concise and carefully planned record of the steps to be taken in the preparation of samples for photo-micrography. Bulletin D-4.

**Ascoloy 55**—Allegheny Steel Co. A technical bulletin describing this chromium iron alloy will be sent on request. Ask for bulletin D-5.

**Rotary Heat Treating Furnaces**—W. S. Rockwell Co. Catalog covering Rockwell rotary heat treating furnaces, retort type. Electric or fuel, for ferrous and nonferrous metals. Ask for bulletin D-6.

**Hardness Testers**—Wilson-Maeulen Co. Bulletin H-9 describing applications of the Rockwell hardness tester to a variety of types of work in many different industries. Bulletin D-7.

**Hy-Ten Steel**—Wheelock, Lovejoy and Co. Hy-Ten steel range in carbon from .10 to 1.00 per cent. There is a Hy-Ten grade for every vital machine part. Bulletin D-8.

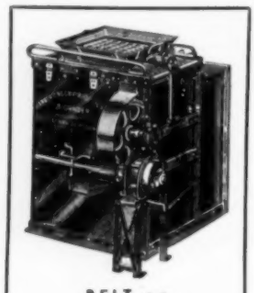
**Fatigue Testing Machine**—Thompson Grinder Co. A bulletin describing the rotating beam type fatigue testing machine. Giving interesting data on fatigue testing. Bulletin D-9.

**Chromel Resistance Wire**—Hoskins Mfg. Co. Catalog and handbook describing Chromel resistance wire and other resistance alloys, also thermocouple alloys, giving technical information and data. Bulletin D-10.

**Nickel Cast Iron**—International Nickel Co. Nickel Cast Iron, Data and Applications. A series of seven 8½ by 11 inch semi-technical bulletins with convenient loose-leaf type binder to facilitate filing and increase their reference value. Bulletin D-11.

**Globar Heating Elements**—Globar Corporation. Bulletin "Globar Non-Metallic Electric Heating Elements" which gives the physical characteristics and applications of Globar elements. Bulletin D-12.

**Steel Treating**—Park Chemical Co. Booklet covering various heat treating processes and chemicals used to properly produce the results desired in the finished product. Bulletin D-13.

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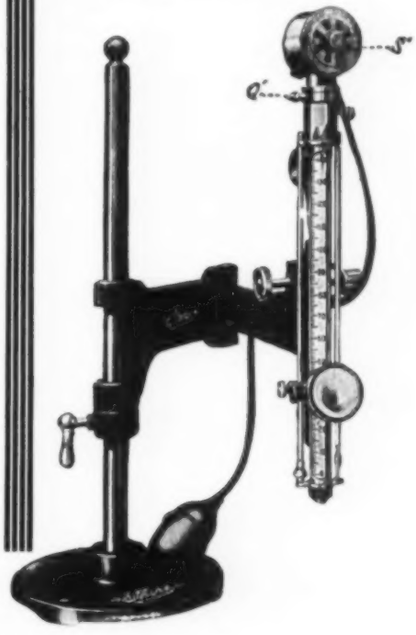

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# THE ENGINEERING INDEX

*In the preparation of the Engineering Index by the staff of the American Society of Mechanical Engineers some 1700 domestic and foreign technical publications are regularly searched. From this material the A.S.S.T. is supplied with this selective index to those articles which deal particularly with steel treating and related subjects.*

REGISTERED UNITED STATES, GREAT BRITAIN AND CANADA

## AIRPLANE MANUFACTURE

WELDING. Welding Processes Used in Making Planes, J. B. Johnson. *Welding*, vol. 1, no. 11, Sept. 1930, pp. 735-738, 8 figs.

Discussion of gas welding, electric arc welding, and resistance welding with regard to ease of application and reliability; physical properties and appearance are compared.

LIGHT ALLOYS. What Heat Treatment Has Done for Aircraft Engine Parts, R. R. Moore. *Iron Age*, vol. 126, no. 11, Sept. 11, 1930, pp. 677-679, and 756-757, 2 figs.

Discussion of physical properties and heat treatment of principal light alloys; effect of chemical composition of heat treating results.

## ALLOYS, HEAT RESISTING

Heat Resisting Alloys in Furnaces, L. J. Stanbery. *Heat Treating and Forging*, vol. 16, no. 8, Aug. 1930, pp. 1031-1035, 4 figs.

Fundamental physical and chemical characteristics of metal alloys to be used at high temperatures; influence of chromium and nickel. (To be continued.)

Behavior of Heat-Resisting Alloys in Presence of Sulphur and a New Sulphur-Resistant Alloy (Der Verhalten hitzebestaendiger Legierungen gegen Schwefel und eine neue schwefelbestaendige Legierung), H. Gruber. *Stahl und Eisen (Duesseldorf)*, vol. 50, no. 36, Sept. 4, 1930, p. 1272.

Increase of resistance against attack of sulphur compounds by means of aluminum addition (alloy no. 8) is attributed to increase in melting point of sulphide-layer formation and to formation of very thin but gas-impervious skin of aluminum oxide. Abstract from Wilhelm Heraeus 70th Birthday special volume.

## ALLOY STEEL

General Principles Underlying the Use of Alloy Steels, R. Whitfield. *Iron and Steel Industry (Lond.)*, vol. 3, no. 11, Aug. 1930, pp. 347-350, 4 figs.

Outline of influence of components on structure and properties of alloy steels; discussion of equilibrium diagrams and constitutional diagrams.

Alloy Steels for Industrial Purposes, R. L. Duff. *Petroleum Mech. Eng. (A.S.M.E.), Advance Papers*, for mtg. Oct. 6-8, 1930, pp. 93-97, 7 figs.

Metallurgical test work involved in their successful adaptation; description of apparatus used; temperature stresses; physical constants; creep theory; creep determination; high-temperature tests other than creep tests; impact testing.

Stamping and Forging Special Steels, A. H. Allen. *Steel*, vol. 87, no. 5, July 31, 1930, pp. 42-46 and 53, 8 figs.

Description of equipment and manufacturing methods at plant of Transue and Williams Steel Forging Corp., Alliance O.; typical examples of experimental and production work on corrosion-resistant and nitride steels are discussed; data on composition and properties of steels are given.

## ALUMINUM ALLOYS

Aluminum and Its Alloys (L'alluminio e le sue leghe), T. Zinelli. *Aeronautica (Milan)*, vol. 8, no. 4, Apr. 1930, pp. 277-288, 18 figs.

Brief outline of use of aluminum in various industries, particularly automotive industries. (Continuation of serial.)

ETCHING. New Etching Reagent for the Macrography of Aluminum and Its Alloys, C. M. Tucker. *Metals and Alloys*, vol. 1, no. 14, Aug. 1930, pp. 655-656, 5 figs.

Description of improved macroetching process for aluminum alloys which can be used on surface prepared by rough machining or with coarse emery paper; method was developed by Aluminum Co. of America and is illustrated by sketches of etched surfaces.

HARDENING. Hardening of Beryllium-Aluminum and Magnesium-Aluminum Alloys (Beitrag zum Haertungsproblem von Beryllium-Aluminium- und Magnesium-Aluminiumlegierungen), M. Haas and D. Uno. *Zeit. fuer Metallkunde (Berlin)*, vol. 22, no. 8, Aug. 1930, pp. 277-279, 8 figs.

Results of authors' tests and diagram of state of binary beryllium alloys; hardening effect; diagram of state of magnesium-aluminum alloys.

## ALUMINUM

CASE HARDENING. The Cementation of Aluminum, R. J. Anderson. *Fuels and Furnaces*, vol. 8, no. 9, Sept. 1930, pp. 1243-1245.

Brief survey of methods tried to date for cementing aluminum, difficulties involved and possible application.

NICKEL PLATING. Nickel-Plating Aluminum (Die Aluminiumvernickelung), E. Werner. *Metallboerse (Berlin)*, vol. 20, no. 52, June 28, 1930, p 1434.

Alkaline plating baths are not suited for nickel deposition on aluminum; intermediate plating with brass or copper is recommended, followed by electrolysis in bath of given composition.

WELDING. Welding Aluminum, W. M. Dunlap. *Aviation Eng.*, vol. 3, no. 7, July 1930, pp. 11-15, 10 figs.

Discussion of welding practice in making fuel tanks of sheet aluminum; strength data on spot-welds are given, and structure illustrated by microphotographs.

## BEARING METALS, BRONZE

Bearing Bronzes with Additions of Zinc, Phosphorus, Nickel, and Antimony. *U. S. Bur. of Standards—Jl. of Research*, vol. 5, no. 2, Aug. 1930, pp. 349-364, 16 figs.

Study was made of copper-tin-lead-bearing bronzes with and without additions of zinc, phosphorus, nickel, and antimony; test made included wear resistance, resistance to impact, Brinell hardness, and resistance to repeated pounding at several temperatures.

## BRIDGES, STEEL

ELECTRIC WELDING. First Welded Bridge of German State Railroad (Die erste geschweisste Reichsbahnbruecke), Witte. *Elektroschweissung (Braunschweig)*, no. 7, July 1930, pp. 140-142, 5 figs.

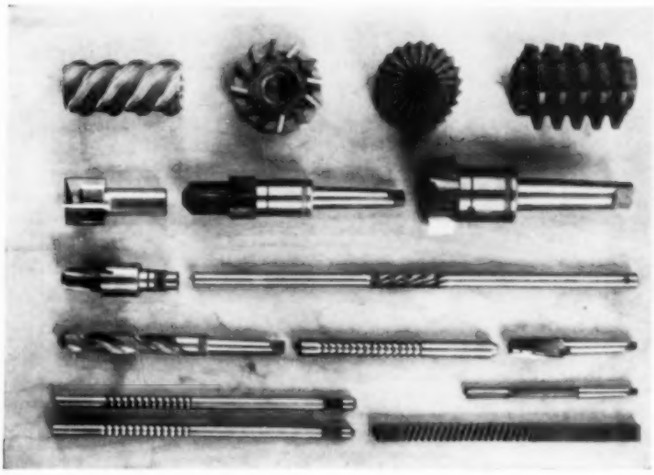
Arc welding of bridge 10 m. span and 3 m. width near Muenster is discussed; tests confirm reliability of welding.

High-Strength Structural Steels. *Iron Age*, vol. 126, no. 1, July 3, 1930, pp. 16-18, 3 figs.

Review of discussion at meeting of American Society for Testing Materials in Atlantic City, N. J.; notes on high-strength structural and ship steel; cold-drawn bridge wire. See also Engineering Index, 1929, p. 1807.

WELDING. Structural Steel and Pipe Line Welding, O. A. Tilton. *West. Machy. World*, vol. 21, no. 6, June 1930, pp. 239-242, 6 figs.

Facts regarding application of fusion welding to fabrication of steel buildings and pipe-lines.



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## CASE HARDENING

CYANIDE BATH. Cyaniding and Salt Bath Working, J. W. Urquhart. *Heat Treating and Forging*, vol. 16, no. 8, Aug. 1930, pp. 989-994, 2 figs.

Procedure of salt-bath hardening, and general heat treatment in salt baths; data on preparation for local hardening; cyanide chlorine baths; use and maintenance of cyanide baths; barium-chloride treatments; tempering salt range.

## CAST IRON

EUTECTIC. High-Strength Cast Iron, Eutectic Cast Iron, F. Osann. *Foundry Trade Jl. (Lond.)*, vol. 43, no. 728, July 31, 1930, p. 75.

Advantages of eutectic alloys. Abstract of paper read before German Foundry Tech. Assn.

HEAT TREATMENT. Wider Use of Heat Treatment for Gray Iron Castings, H. Bornstein. *Iron Age*, vol. 126, no. 11, Sept. 11, 1930, pp. 688-690 and 756-757, 5 figs.

Discussion of artificial aging, annealing to reduce hardness and increase machinability and quenching to increase hardness and strength; tables give data on physical properties of heat treated castings and results of annealing regular and alloy cast iron.

MACHINABILITY. Machinability of Cast Iron, E. J. Lowry. *Am. Soc. Testing Matls.—Proc.*, part 2, vol. 29, 1929, pp. 126-127.

Paper discusses factors which influence machinability; although machinability of cast iron is function of abrasion, hardness, and ductility, hardness alone cannot be considered as true indicator of machinability since it does not measure abrasive quality of metal; any influence which tends to eliminate abrasiveness increases machinability; such as annealing, higher silicon content, higher carbon content or addition of nickel, titanium, or any other softening alloy.

TESTING. The Testing of Cast Iron, J. W. Donaldson. *Metallurgia (Manchester)*, vol. 2, no. 10, Aug. 1930, pp. 121-124.

Modern engineering and construction developments have made new demands on cast iron; many factors have to be considered; testing methods; transverse, tensile, compression, shear, fatigue, impact, hardness, and wear tests are discussed. Bibliography.

Effect of Melting Conditions on Gray Cast Iron, A. L. Norbury and E. Morgan. *Fuels and Furnaces*, vol. 8, no. 8, Aug. 1930, pp. 1083-1084.

Discussion of effect of melting conditions such as superheating, additions of steel, silicides, graphite, gases and iron oxide on microstructure and mechanical strength of gray cast irons; results of tensile, transverse, repeated impact, Brinell, drill-hardness and specific gravity tests.

## CHROMIUM-VANADIUM STEEL

Vanadium Additions Improve Steel, N. Petinot. *Steel*, vol. 87, nos. 8, 9, 10, Aug. 21, 1930, pp. 43-45 and 48, Aug. 28, 1930, pp. 47-49 and Sept. 4, pp. 56-57, 60, 7 figs.

Development of vanadium-containing steels in United States, properties and present application in major industries; effects of vanadium upon steels; properties of vanadium steels and discussion of commercial applications; use of vanadium as process element. Paper read before sixth International Congress of Min., Metallurgy and Applied Geology held in Liége, Belgium, June 22-28, 1930.

## DIE CASTINGS

Modern Die-Casting Practice, E. V. Pannell. *Engineer (London)*, vol. 150, nos. 3892 and 3893, Aug. 15, 1930, pp. 168-169, and Aug. 22, pp. 193-194, 2 figs.

Aug. 15: Survey of present status of art of casting non-ferrous metals by pressure; modern factory devoted to production of die casting will consist mainly of five departments: (1) metal melting, (2) die casting, (3) trimming, (4) enameling and plating, (5) die making, die-casting machines. Aug. 22: Steel molds or dies used in die-casting industry; metals and alloys.

*(Continued on page 166)*


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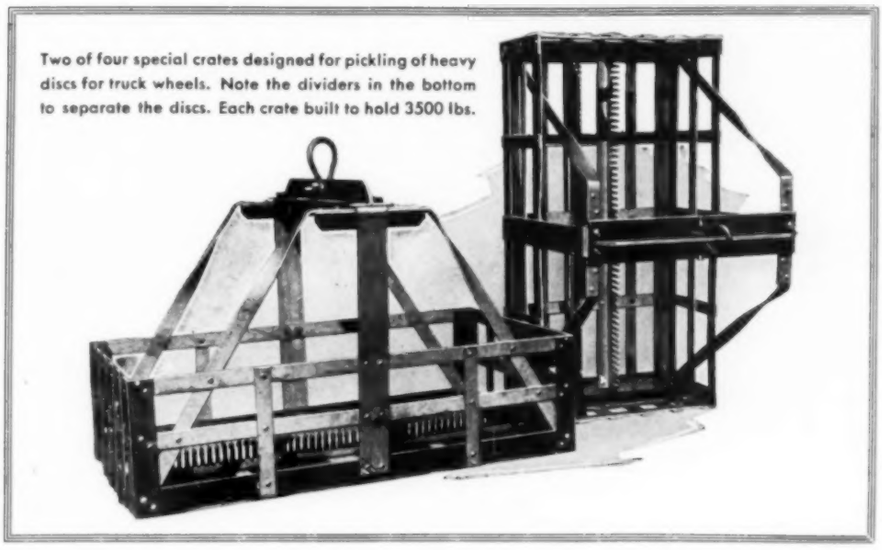

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Compressed Metals (Les Métaux comprimés), G. Batta and J. Dessent. *Revue Universelle des Mines (Liege)*, vol. 73, no. 5, Mar. 1, 1930, pp. 133-135, 6 figs.

Greater resistance has been developed by employing method of making castings under pressure and by compression; these methods impart to non-ferrous alloys properties of laminated material; first process greatly improves quality of metal, giving it fine grained structure, but does not remove danger of air bubbles; second method does not have this defect but must be used only on very pure metal, otherwise malleability is reduced and cracks appear.

## DIES

BENDING. Schnitte und Stanzen, Bd. 2; Biegestanzen und Biege-Verbundwerkzeuge, E. Goehre. Lpz. Otto Spamer, 1930, 230 pp., illus., 23.-r.m.

Second volume of this treatise on punching and stamping treats of bending dies; methods of achieving various forms are described in detail, aim being to assist engineer in designing suitable dies for desired shape; further volumes will discuss drawing dies and die construction. Eng. Soc. Lib., N. Y.

FORGING. Use of Special Steels for Forging Dies (Die Verwendung von Sonderstaehlen fuer die Anfertigung von Pressgesenken), V. Fabian. *Maschinenbau (Berlin)*, vol. 9, no. 17, Sept. 4, 1930, pp. 582-583, 6 figs.

Discussion of experience with special steel of uniform hardness which increases life of dies from 5 to 40 times; data on composition and heat treatment are given.

Correct Design and Heat Treatment of Steel Dies for Die Castings, R. L. Johnson. *Iron Age*, vol. 546-548 and 576.

Discussion of important points of mechanical design; chemical composition and heat treatment of alloy steel dies; die life is from 15,000 to 200,000 castings.

## ELECTRIC FURNACES

BRAZING. Copper Brazing in Electric Furnaces. *Machy. (Lond.)*, vol. 36, no. 935, Sept. 11, 1930, pp. 758-759, 3 figs.

Description of method and equipment for fabricating drawn and cast steel parts by copper brazing in electric furnace with hydrogen atmosphere.

ELECTRODE REGULATION. New Method of Regulation of Electric Electrode Furnaces (Un nouveau mode de réglage des fours électrique a électrodes), P. Bergeon. *Jl. du Four Electrique (Paris)*, vol. 39, no. 6, June 1930, pp. 209-211, 2 figs.

New method developed by P. Mignet and M. Pierron consists of varying voltage at electrodes instead of displacing electrodes themselves; this way of regulation had been successfully applied on two 4000 kw. furnaces of Société Belge d'Electrochemie in Langerbrugge.

INDUCTION. The Coreless Induction Furnace, A. G. Robiette. *Metallurgia (Manchester)*, vol. 2, no. 9, July 1930, pp. 105-108, 4 figs.

Discussion of some features of design and operation; distinguishing features as contrasted with other so-called low-frequency induction furnaces, is return to familiar and convenient shape of crucible furnaces; recent development is Rohn fritting process for furnace lining; development of basic lining.

METALLURGICAL. Bibliographie der Elektrometallurgie des Technischen Eisens, edited by E. Kothny, Berlin, Verein Deutscher Giessereifachleute, 1930, 66 pp., 6. r-m.

Bibliography of electrometallurgy of commercial iron, preparation of which was authorized by Elektroofen-Ausschuss des Vereins Deutscher Giessereifachleute (Electric Furnace Committee of Society of German Foundrymen); contains author index and bibliography covering design equipment and operation of electric furnaces, electric steel making, pig-iron manufacture, electric foundry practice, heat treatment, etc.

*(Continued on page 168)*


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### ELECTRIC HEATING ELEMENTS

The Development and Application of Non-Metallic Electric Heating Elements. *Metallurgia (Manchester)*, vol. 2, no. 10, Aug. 1930, pp. 137-139, 7 figs.

Development of material is result of various scientific investigations and material has consisted primarily of silicon carbide; by commencing to burn silicon-carbide and silicon together in atmosphere of nitrogen, formation of silicon-nitrogen compound binds substance into dense, firm bodies; test data and graphs of electric properties of such materials.

### ELECTRIC WELDING

ARC. Alternating-Current Arc Welding (Die Wechselstrom Lichtbogenschweissung), W. Schueller. *Elektroschweissung (Braunschweig)*, no. 8, Aug. 1930, pp. 163-164, 1 fig.

Notes on selection of proper welding machine; kind of current, power consumption, strength and stretch of welded products.

ARC. Modern Arc-Welding Practice, J. M. Hipple and G. D. Fish. *Welding Engr.*, vol. 15, no. 9, Sept. 1930, pp. 49-54, 6 figs.

Weld forms and various cases of loading; arc-welded connections for buildings and bridges; allowable working stresses; welding and riveting practice compared; welding of machine structures; advantages of fabricated and welded structures; materials used; training welders and checking their work; equipment; types of welds. From paper presented at Int. Congress of Steel Construction, Belgium.

RESISTANCE CONTROL. Thyratron Control Equipment for High-Speed Resistance Welding. R. C. Griffith. *Gen. Elec. Rev.*, vol. 33, no. 9, Sept. 1930, pp. 511-513, 8 figs.

In interrupted line welding, service requirements of control device are particularly severe; for this reason application has been made of Thyratron tube as make-and-break device in control equipment; control system and features are discussed.

### FORGINGS, COPPER BASE

Copper-Base Forgings and Die-Pressed Parts, H. Chase. *Product Eng.*, vol. 1, no. 8, Aug. 1930, pp. 362-363, 4 figs.

Description of two similar processes for production of commercial copper-base forgings; advantages of forged or die-pressed parts over sand-castings; photomicrographs showing relatively coarse grain structure of brass sand-casting as compared to finer grain structure of brass die-pressed part.

### FURNACES

INDUSTRIAL. American Machinist 1930 Inventory of Metal-Working Equipment. *Am. Mach.*, vol. 73, no. 12, Sept. 18, 1930, p. 471.

Inventory and classification of various types of furnace equipment in industrial plants; figures of 1920 and 1929 are compared.

Scientific Thermal Principles of Industrial Furnaces (Les bases scientifiques thermiques des fours industriels), G. Zotos. *Revue de Métallurgie (Paris)*, vol. 27, no. 7, July 1930, pp. 352-361, 4 figs.

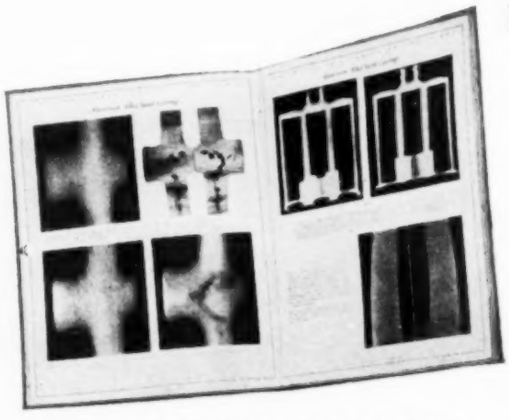
Production of heat at elevated temperature; technical interpretation of laws of radiation; it is claimed that elevation of temperatures is not feasible with actual furnaces, because refractory materials cannot resist flame temperatures that are too high; when this difficulty has been overcome by new type of furnace of direct action, new future will be open to flame furnace, recently so menaced by the less economic electric furnace.

MELTING, OIL FIRED. Metal Melting by Oil Fuel, W. C. Cathcart. *Foundry Trade Jl. (Lond.)*, vol. 43, no. 728, July 31, 1930, pp. 77 and 80.

Comparison of gas, electricity and oil as fuel; cost of oil-fired furnaces; quality of metal melted.

*(Continued on page 170)*


# Which Use of the X-Ray might interest you—



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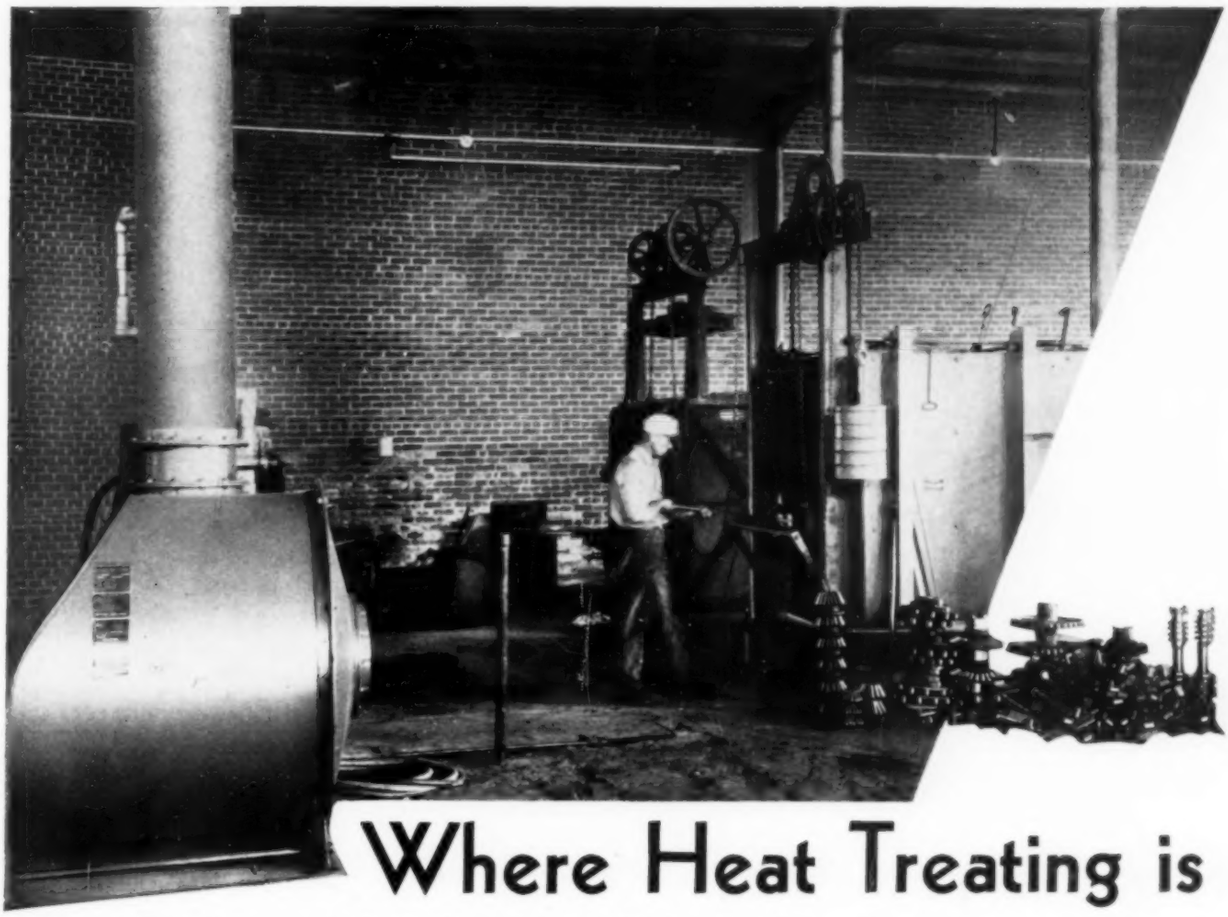

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## IRON-NICKEL ALLOYS

MAGNETIC PROPERTIES. Materials with High Initial Permeability (Ueber Materialien mit hoher Anfangspermeabilitaet), E. Gumlich, W. Steinhaus, A. Kussmann and B. Scharnow. *Elektrische Nachrichten-Technik (Berlin)*, vol. 7, no. 6, June 1930, pp. 231-235, 6 figs.

Magnetic and electric properties of reversible nickel-iron alloys with 5, 10 and 15 per cent of manganese; various possibilities to combine relatively high initial permeability with little dependence of permeability on field strength, are investigated.

CORROSION. The Corrosion Rate of Ferro-Nickel Alloys, C. G. Fink and C. M. DeCroly. *Am. Electrochem. Soc.—Trans.*, vol. 56, for mtg. Sept. 19-21, 1929, pp. 239-273 and (discussion) 273-277.

Tests made on commercial alloys of iron-nickel series, using intermittent corrosion test, as this more nearly approaches actual service conditions; specifications laid down by American Society for Testing Materials were followed as closely as possible; rate of corrosion in sulfuric acid increases at first very rapidly with concentration of acid, reaches maximum, then decreases again, reaching minimum, and usually increases again to reach second maximum. (See Engineering Index, 1929, p. 777.)

## IRON AND STEEL

CORROSION. On Ferric Hydroxide Which is Formed in Rusting (Ueber das beim Rostvorgang Auftretende Eisen(III)hydroxyd), G. Schikorr. *Zeit. fuer anorganische und allgemeine Chemie (Leipzig)*, vol. 191, no. 4, Aug. 19, 1930, pp. 322-332, 1 fig.

Report from Materials Testing Laboratory of Berlin-Dahlem on chemistry of rusting of iron; moisture content of rust at various temperatures.

ELECTRIC PROPERTIES. Iron and Steel Used in Electrical Engineering, L. E. Benson. *Elecn. (Lond.)*, vol. 105, no. 2723, Aug. 8, 1930, pp. 170-173, 12 figs.

Notes on wrought materials; carbon steel; mild steel and wrought iron; alloy steels; melting and casting of steels; forging and heat treatment; table showing physical properties of various wrought steels; composite photomicrograph to show effect of heating on mild steel.

MANGANESE DETERMINATION. Methods for Determining Manganese, R. P. Hudson. *Heat Treating and Forging*, vol. 16, no. 8, Aug. 1930, pp. 1009-1010.

Review of various methods for determining manganese in iron and steel; Volhard's process; Crobaugh's modification; bismuthate process; color method; persulphate-arsenite method.

PROTECTIVE COATINGS. Protection of Ferrous Metals by Metallic Coatings and by Chemical Means (La protection des métaux ferreux par les revetements Métalliques et par voie chimique), J. Bourgarel. *Technique Moderne (Paris)*, vol. 22, no. 15, Aug. 1, 1930, pp. 529-534, 2 figs.

Outline of various methods with regard to corrosive agent, cost of production and surface finish; table gives data on corrosion tests for different conditions of atmosphere and water.

## MANGANESE ALLOYS

Physical Properties and Heat Treatment of Alloys of the Manganin Type, S. Zhemchuzhny and S. Pogodin. *Trudi Instituta Metallov (Moscow)*, no. 8, 1930, pp. 3-39, 11 figs.

Report on laboratory study of effect of heat treatment on properties of manganin alloys, undertaken for purpose of obtaining special manganin alloys for construction of resistance coils of electrical measuring apparatus; several alloys obtained having electrical properties equivalent to those of German manganin. (In Russian, with brief English Abstract.)

Manganese and Its Alloys (Le manganese et ses alliages), R. Cazaud. *Aciers Spéciaux, Metaux et Alliages (Paris)*, vol. 5, no. 58, June 1930, pp. 271-278, 10 figs.

Data on production, consumption and physical properties of manganese are given; effect of manganese upon structure of various steels is discussed and illustrated by graphs; notes on manganese and copper alloys and aluminum alloys.

X-RAY ANALYSIS. The Iron-Manganese System. *Metallurgist (Supp. to Engineer Lond.)*, Aug. 1930, pp. 123-125, 2 figs.

Review of two papers dealing with X-ray examination of iron-manganese system of alloys; investigation by A. Osawa in Science Reports of Tohoku Imperial Univ., series 1, vol. 19, no. 2, contains accounts of results of X-ray analysis and density and hardness measurements of series of alloys at room temperatures; second contribution is by E. Oehman in Zeit. fuer Physikalische Chemie, vol. 8, no. 1/2, and represents attempt to construct constitutional diagram from X-ray data obtained at room and elevated temperature.

## MANGANESE STEEL

HEAT TREATMENT. Heat Treatment Determines Properties of Manganese Steel, H. P. Evans. *Foundry*, vol. 58, no. 17, Sept. 1, 1930, pp. 102-103.

Methods of obtaining proper structural characteristics of various properties; mechanism of structural change brought about by heat treatment is explained.

DRILLING. New Tools Successfully Cut High-Manganese Steels, W. R. Breeler. *Steel*, vol. 87, no. 6, Aug. 7, 1930, p. 67, 2 figs.

Notes on drilling manganese steel by means of cobalt steel drills; sketch shows correct angles of point and clearance of twist drill.

## METALLOGRAPHY

Report of Committee E-4 on Metallography. *Am. Soc. for Testing Matls.—Proc.*, part 1, vol. 29, 1929, pp. 505-512, 10 figs. on supp.

Article indexed in Engineering Index 1929, pp. 1146 and 1147, from Preprint no. 25, for mtg. June 24-28, 1929.

## METALS

COLD WORKING. Cold Working and Young's Modulus, T. Kawai. *Metallurgist (Supp. to Engineer, Lond.)*, Aug. '30, pp. 115-116.

In addition to effect on Young's modulus of cold working and of moderate heating of stretched or drawn bars in boiling water, effect of annealing at progressively increasing temperatures was also examined; main results are summarized; both ferrous and nonferrous metals were examined. Review of research work reported in no. 2, series I, vol. 19, of Science Reports, Tohoku Imp. Univ.

CORROSION. The Corrosion of Metals, H. Sutton. *Aircraft Eng. (Lond.)*, vol. 2, no. 18, Aug. 1930.

Recent researches on light alloys and steels, with applications to construction of seaplanes; notes on effect of heat treatment of duralumin on resistance to intercrystalline corrosion; discussion of anodic process.

The Theory of Corrosion, C. E. Richards. *Post Office Elec. Engrs.—Jl. (Lond.)*, vol. 23, part 2, July 1930, pp. 138-141.

Brief note on modern electrochemical theory of metallic corrosion in its most usual form.

DEFORMATION. Some Applications of the Theory of Plastic Deformations of Ductile Metals, A. Nadai. *Phys. Rev.*, vol. 36, no. 4, Aug. 15, 1930, pp. 762-772, 4 figs.

Account of principal conditions which are available to express equilibrium of stress in plastic or ductile metals; ease of rotationary symmetry in plastic body; plastic flow in thick-walled cylinder subjected to high internal pressure with and without longitudinal expansion; distribution of stress during yielding for long cylinder and for flat ring, both subjected to radial pressure; spread of yielding and plastic deformation through walls of cylinder.

HARDENING. Lattice Distortion as Factor in the Hardening of Metals, W. L. Fink. *Inst. of Metals—Advance Paper (Lond.)*, no. 534, for mtg. Sept. 9-12, 1930, 7 pp.

Rockwell hardness measurements and diffraction patterns showed that lattice distortion can be accompanied by appreciable softening in externally stressed aluminum alloy (178) or alpha brass; curve representing stress vs. hardness relations in elastic range is given; maximum lattice distortion and minimum hardness are necessarily coincident in age-hardening alloys; considerable caution should be exercised in attributing hardening of metals to lattice distortion.

*(Continued on page 172)*

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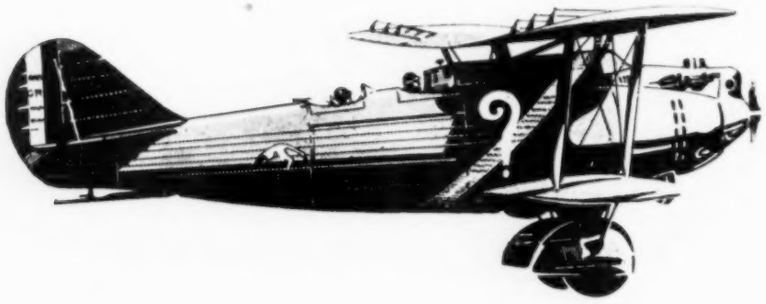

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## NITRIDATION

Case-Hardening with Ammonia Gas, V. O. Homerberg and J. P. Walsted. *Am. Soc. Mech. Engrs. —Advance Paper, for mtg.*, Sept. 22-24, 1930, 6 pp., 9 figs.

Explanation of process of case hardening by means of ammonia; properties of nitralloy steel after heat treatment and before and after nitriding; wear resistance of nitrided surfaces.

Nitriding Analyses — Their Physical Properties and Adaptability, R. S. Sergeson and M. M. Clark. *Am. Soc. of Mech. Engrs. —Advance Paper*, for mtg. Sept. 22-24, 1930, 8 pp., 22 figs.

Range of analyses of present chrome - aluminum - molybdenum nitriding steels; physical properties of these analyses in regard to tensile and impact values; data on fatigue tests; proper quenching temperatures; suggestion as to amount of stock to be removed for elimination of decarburized surface obtained previous to machining; many applications which are operating successfully are given.

Nitriding Process of Nitrogen Case Hardening, J. E. Hurst. *Iron and Steel Industry (Lond.)*, vol. 3, no. 11, Aug. 1930, pp. 351-354, 5 figs.

Discussion of factors effecting nitriding process in various kinds of steel; table gives chemical composition of various steels used in nitridation trials; typical methods of application of process for crankshafts, gears, tappets, pins, camshafts and dies; notes on removal of internal stresses. (To be concluded.)

Properties and Uses of Nitrided Steel, H. A. Defries. *Machine Design*, vol. 2, no. 8, Aug. 1930, pp. 31-34, 8 figs.

Outline of three nitriding operations and physical properties of nitralloy for various purposes such as gears, shafts, etc.

## NON-FERROUS METALS

ACID RESISTING. Production of Alloys, Designated as Acid Resisting (Die Erzeugung von Metallegierungen, die als saeurefest gelten), R. Nitzsche. *Zeit. fuer die Gesamte Giessereipraxis (Berlin)*, vol. 51, no. 34, Aug. 24, 1930, *(Metall)* pp. 137-138.

Alloys considered are phosphorus, manganese, manganese-nickel and aluminum bronzes, some aluminum alloys, and special brasses; in production of these alloys, essential factors are proper choice of basic materials, and melting process.

ANNEALING. Heat Treatment of Non-Ferrous Metals, A. H. Vaughn. *Heat Treating and Forging*, vol. 16, no. 8, Aug. 1930, pp. 1036-1041, 8 figs.

Discussion of heat-treating processes and equipment for brass, copper and light alloys, particularly aluminum alloys; advantages of electric furnaces are outlined, especially for continuous production.

*(Continued on page 174)*

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BETWEEN 1908 and 1929 the manufacturers of a famous line of pneumatic tools and rock drills purchased 15 industrial furnaces and six soda kettles — designed, built and installed by *Strong, Carlisle & Hammond* Engineers. One of their carburizing furnaces used for hardening small parts of tools and drills is shown.

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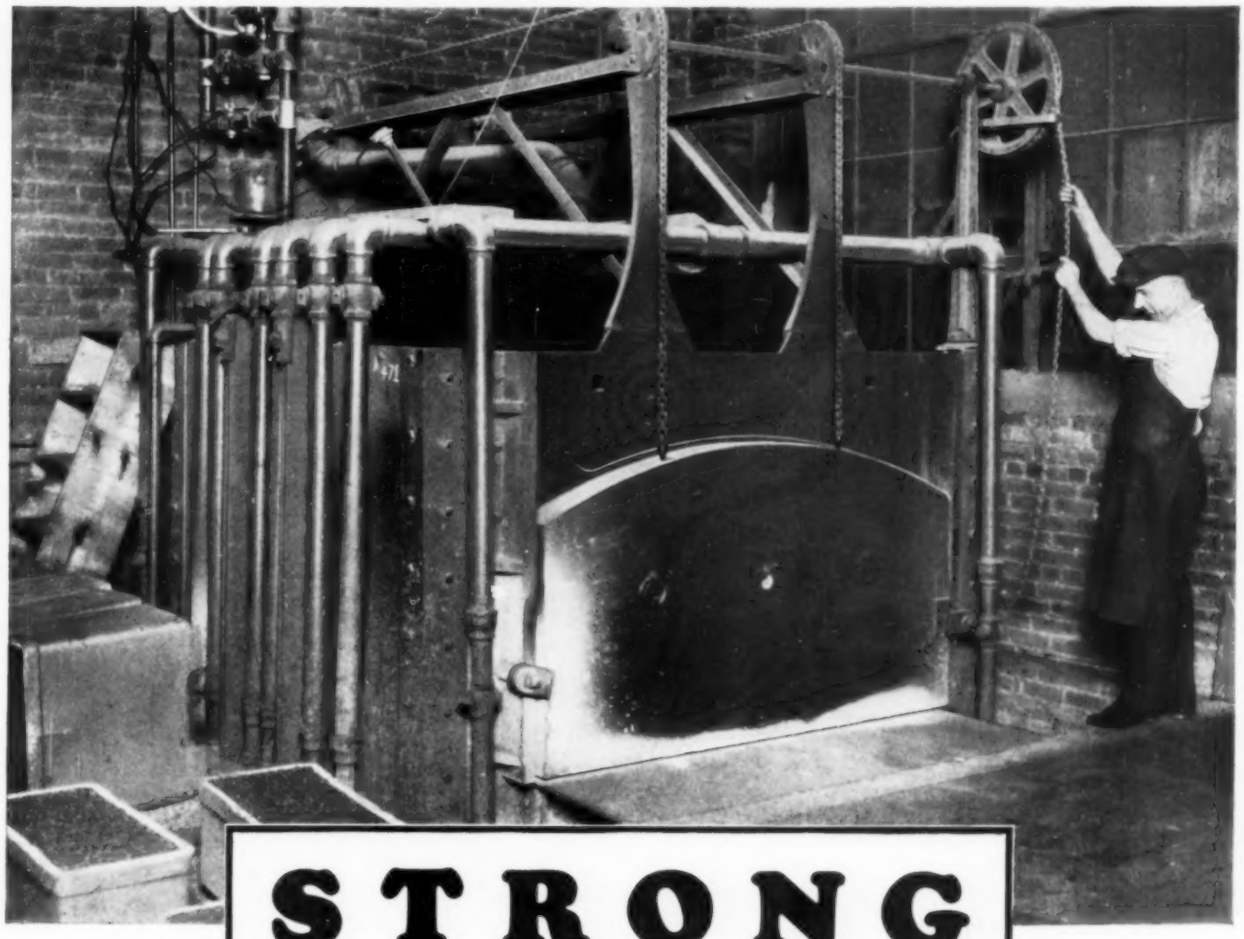

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DEOXIDIZERS. Manganese and Silicon as Deoxidizers, E. Thews. *Metal Industry (Lond.)*, vol. 37, no. 5, Aug. 1, 1930, pp. 99-102.

Constitutions of maganese, manganese-copper, silicon, silicon-copper, cupro-silicon and silicon brasses given with their uses as deoxidizers.

METALLOGRAPHY. A Study of the Relation Between Macro- and Microstructure in Some Non-Ferrous Alloys, M. L. V. Gayler. *Inst. of Metals—Advance Paper (Lond.)*, no. 535, for mtg. Sept. 9-12, 1930, 12 pp., 23 figs.

Results of previous investigation are confirmed, i.e., the higher the temperature from which alloy is cast the coarser becomes macrostructure, and at the same time microstructure becomes finer, but in less marked degree; macro- and microstructure of alloy does not seem to be affected by various gases, provided casting temperature is kept low; if casting temperature is raised, atmosphere to which molten metal is exposed has very marked effect on macrostructure.

## OPEN-HEARTH FURNACE PRACTICE

The Decarburization of Iron in the Open-Hearth Furnace and the Concentration of Free Ferrous Oxide in Basic Slags, H. Schenck. *Metals and Alloys*, vol. 1, no. 14, Aug. 1930, pp. 674-677, 7 figs.

Investigation of effect of carbon contents of metal and its relation to concentration of free ferrous oxide (FeO); various conceptions as to constant (FeO) were discussed. Translated from Archiv fuer das Eisenhuettenwesen, Mar. 1930, previously indexed.

Reaction and Temperature, M. J. Conway. *Iron and Steel Engr.*, vol. 7, no. 8, Aug. 1930, pp. 425-428.

Discussion of chemical reaction in basic open-hearth process; notes on manganese, sulphur, phosphorus, carbon, and lime; tables give analysis of open-hearth materials and data relating to materials used in finishing steel.

## OXYACETYLENE WELDING

ACETYLENE GENERATORS. Portable Oxyacetylene Plant. *Engineering (Lond.)*, vol. 130, no. 3368, Aug. 1, 1930, pp. 156-157, 3 figs.

Particulars of generators which have been utilized on number of bridge-cutting contracts on Southern Railway and to lesser extent for similar work on other railways.

OXYACETYLENE CUTTING. Tests on Flame-Cut I-Beam Clips, W. S. Wolfe. *Eng. News Rec.*, vol. 105, no. 3, July 17, 1930, p. 101, 2 figs.

Report on tests of flame-cut clips; results of bending tests indicate that all test pieces withstood very high unit stresses as well as severe distortion; none of test pieces cracked.

Autogenous Cutting of Structural and Alloy Steels (Ueber das autogene Schneiden von Baustaehlen und legierten Staehlen). *Autogene Metallbearbeitung (Halle)*, vol. 23, nos. 11 and 13, June 1, 1930, pp. 166-173, July 1, pp. 205-211, 31 figs.

Investigation of cutting effect on high carbon steel, cast iron, silica and manganese steel; tests on surface machinability and notes on heat treatment of steel subjected to autogenous cutting. (Concluded.)

WELDING. Gas-Welded Sheet Metal Products. *Welding*, vol. 1, no. 9, July 1930, pp. 619-622, 9 figs.

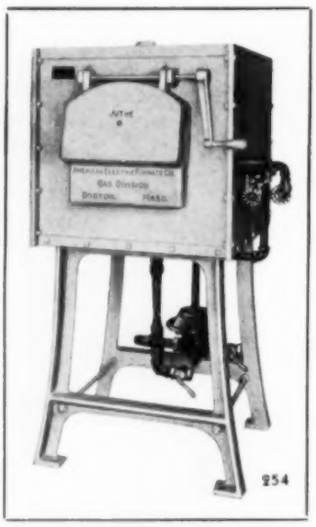
Use of welding in manufacture of hospital equipment, metal furniture, metal doors and sash, steel barrels, sheet metal in airplane manufacture and for other types of products.

## PIPE STEEL

ELECTRIC WELDING. New Welding Process Makes Light Pipe, J. W. Hill. *Oil and Gas Jl.*, vol. 29, no. 14, Aug. 21, 1930, pp. 72-73, 3 figs.

Development of long-distance pipe lines for gasoline and natural gas has increased demand for large pipe to stand high pressure needed for oil and gas transportation; electric resistance method produces 16-in. pipe standing 800 lb. working pressure and weighing 42,053 lb. per ft.

*(Continued on page 176)*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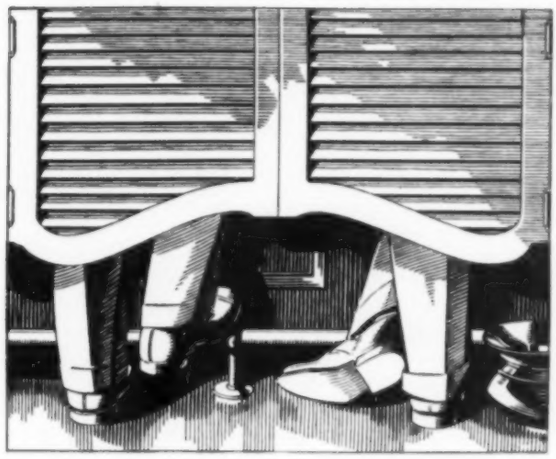

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### PIPE WELDING

How to Weld Steel and Wrought Iron Pipe. *Domestic Eng. (Chicago)*, vol. 132, no. 4, Aug. 23, 1930, pp. 98, 100, 102 and 104-105, 7 figs.

Standards are given covering bends, swages, ends, headers, preparation for welding operation, testing, and form of specification of material. (Continuation of serial.)

How to Weld Steel and Wrought Iron Pipe. *Domestic Eng. (Chicago)*, vol. 132, no. 2, July 26, 1930, pp. 104-108, 110, 8 figs.

Standards for welding adopted by Heating and Piping Contractors National Association. (To be continued.)

WELDING. In Testing Pipe Welds, R. L. Hamilton. *South. Power Jl.*, vol. 48, no. 8, Aug. 1930, pp. 74 and 76, 4 figs.

Summary of principles of testing which should be considered in determination of quality of welds in low and high-pressure piping; various recommendations as to method and technique are given.

### PRESSURE VESSELS

FORGING. Manufacture of Large Weldless Forged-Steel Pressure Vessels, J. L. Cox. *Am. Soc. Mech. Engrs.—Advance Paper for mtg.*, Sept. 24-26, 1930, 9 pp., 31 figs.

Various steps taken in manufacture of large weldless forged steel cylinders for high-pressure boiler drums and for various uses in oil-refining and chemical industries; melting, casting and heating of ingot; cutting-off, piercing, and expanding billet; forging, treating, and machining cylinder.

Ministerial Decree of March 25, 1930, Relative to Application of Autogenous Welding in Manufacture and Repair of Pressure Vessels (Arreté Ministériel du 25 Mars 1930 relatif a l'usage de la soudure autogène dans la construction et la réparation des appareils a vapeur), Falcoz. *Asociations Francaises de Propriétaires d'Appareils a Vapeur—Bul.*, no. 40, Apr. 1930, pp. 73-90.

Text of ordinance signed by Falcoz, under-secretary of State to Minister of Public Works; note is included on precautions to be observed in each of autogenous welding processes.

### SPONGE IRON

Sponge Iron and Its Relation to the Steel Industry, E. P. Barrett. *Min. and Met.*, vol. 11, no. 284, Aug. 1930, pp. 395-396.

Variables to be considered in making an estimate of cost of producing sponge iron are raw materials, plant, and operation; these are briefly discussed; sponge iron should be considered only as raw material for production of high-grade steel; no sponge iron process can be considered as competitor of blast furnace for the production of pig iron on a truly commercial basis.

*(Continued on page 178)*

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## STEEL

ANNEALING. Changes of Structure with Annealing of Mild Steel (Gefuegeaenderungen beim Gluehen von weichem Stahl), W. Heike and W. Brenscheidt. *Archiv fuer das Eisenhuettenwesen (Duesseldorf)*, vol. 4, no. 2, Aug. 1930, pp. 99-103, 8 figs.

Conditions governing origin of column-shaped crystallites with annealing of steel; new method of indicating stresses; displacement of carbon from phosphorus-rich spots; influence of degree of deformation; grain growth.

CEMENTITE EFFECT. Influence of Cementite on Flame Sensitivity, Tendency to Hardening, and Hardness Crack Formations of Carbon Steel (Ueber den Einfluss der Zementitformen auf die Feuerempfindlichkeit, die Neigung zur Durchhaertung und Haerterissbildung von Kohlenstoffstahl), S. Steinberg. *Stahl und Eisen (Duesseldorf)*, vol. 50, no. 33, Aug. 14, 1930, pp. 1164-1166, 5 figs.

Theoretical principles and results of experiments; testing of ductility; favorable action of lamellar cementite.

EMBRITTLEMENT. Brittleness-Embrittlement Phenomena in Steels (Sproedigkeitserscheinungen bei Stahl), O. Schwarz. *Maschinenbau (Berlin)*, vol. 9, no. 14, July 17, '30, pp. 471-474, 9 figs.

Discussion of importance of and tests for ductility; behavior of steel at various temperatures, brittleness as result of age, non-ageing steel; notes on various other factors affecting ductility and brittleness.

FOUNDRY PRACTICE. Complexities in the Steel Foundry, F. A. Melmoth. *Heat Treating and Forging*, vol. 16, no. 8, Aug. 1930, pp. 1006-1008 and 1014.

Discussion of metallurgical and heat-treating problems in manufacture of steel castings. Address before Steel Founders' Soc. of America.

MANUFACTURE. Practical Observations on Manufacture of Basic Open-Hearth High-Carbon Killed Steel, W. J. Reagan. *Am. Inst. Min. and Met. Engrs.—Tech. Pub.*, no. 347, for mtg. Sept. 1930, 16 pp., 5 figs.

All material described is basic open-hearth steel with carbon, 0.50 to 0.85 per cent; phosphorus and sulphur, 0.04 max.; silicon, 0.15 to 0.35; manganese, 0.50 to 0.75; all of this material is bottom-cast; raw materials; design of ingot mold; ladles; open-hearth practice; pouring; effect of analysis on rejections; basic open hearth versus acid open hearth.

## STEEL ANALYSIS

MANGANESE DETERMINATION. Methods for Determining Manganese, R. P. Hudson. *Blast Furnace and Steel Plant*, vol. 18, no. 7, July 1930, pp. 1152-1153.

Volhard's process and Crobaugh's modification; manganese value of permanganate of potash; bismuthate process; persulphate-arsenite method.

## STEEL CASTINGS

Use of Special Cast Steels in Modern Mechanical Construction (l'emploi des aciers moules speciaux dans la construction mecanique courante). Coiscault. *Arts et Metiers (Paris)*, no. 116, May 1930, pp. 202-210, 8 figs.

Comparison of American and French practice in specification of steel; notes on steel foundry practice; requirements of special cast steel; testing strength properties; applications.

CLEANING. Straight-Line Cleaning of Castings on Conveyors, E. F. Miltenberger. *Iron Age*, vol. 126, no. 1, July 3, 1930, pp. 5-9, 7 figs.

Methods and equipment used in cleaning of castings at plant of Eastern Steel Castings, Newark, N. J.; notes on conveyor system.

Rapid Methods for the Chemical Analysis of Special Steels, Steel-Making Alloys, their Ores, Graphites and Bearing Metals, C. M. Johnson. 4th edition. N. Y., John Wiley & Sons, 1930, 729 pp., illus., tables, $7.50.

This well-known manual for steel-works chemist has been enlarged and revised by addition of nearly two hundred pages of new methods and modifications of old ones; methods are given for handling all materials that are usually met in laboratories of makers of special steels. Directions are full and specific. Eng. Soc. Lib., N. Y.

HEAT TREATMENT. Effect of Cooling Rate on the Properties of Steel Castings, W. J. Crook, D. J. Martin and J. W. Halley. *West. Machy. World*, vol. 21, no. 7, July 1930, pp. 311-314, 8 figs.

Experiments and theories of dendritic structure; dendritic structure and its relation to cooling rate; data on physical properties and microphotographs illustrate results.

## WELDED STEEL STRUCTURES

DESIGN. Tentative Welding Specification for Steel Structures (Der neue Entwurf zu "Richtlinien fuer die Ausfuehrung geschweisster Stahlbauten"). *Stahlbau (Berlin)*, vol. 3, no. 9, May 2, 1930, pp. 105-107; see also brief translated abstract in *Bldg. Science Abstracts*, vol. 3, no. 5, May 1930, p. 189.

Specification by committee appointed by Verein Deutscher Ingenieure, intended as supplement to regulations for steel structures; covers calculations and permissible stresses, tests for welding personnel, tests of welds, and procedure on site; electric arc welding is considered standard practice, but gas and resistance welding are permitted.

Control of Quality in Electrically Welded Steel Structures, A. R. Moon. *Instn. of Engrs. Australia—Jl. (Sydney)*, vol. 2, no. 7, July 1930, pp. 258-265, 2 figs.

Paper discusses possibility of standardized practice to ensure quality of weld, by use of procedure which controls heat conditions to which weld metal is submitted during deposition and cooling; properties of welds deposited in runs of different size; influence of plate thickness and welding current on impact strength of weld; influence of oxides; relation of welding current to time of deposition and energy used; costing and estimating; suggested specifications for control of arc welding; measurement of elongation.

## WELDING, ELECTRIC VS. OXYACETYLENE

Why Does Metallurgical Industry Change from Gas to Electric Arc Welding (Aus welchen Gruenden geht die Huettenindustrie von der Gasschmelzschweissung zur Lichtbogenschweissung ueber), K. Drescher. *Elektroschweissung (Braunschweig)*, no. 7, July 1930, pp. 142-144, 2 figs.

Comparative study of two methods; tabulation of costs and of quality of welding obtained; on basis of these it is suggested that metallurgists investigate which method is best in quality and cost.

TESTING. Critical Discussion of Test Methods for Welded Seams (Kritische Betrachtung der Pruefverfahren fuer Schweissnaehte), H. Kemper. *Autogene Metallbearbeitung (Halle)*, vol. 23, no. 13, July 1, 1930, pp. 199-205, 10 figs.

General discussion of test methods covers particularly bending and elongation tests and equipment; sketch shows text fixtures.

## X-RAYS

METALS ANALYSIS. X-Rays and Metals. *Metallurgist (Supp. to Engineer, Lond.)*, Aug. 1930, pp. 114-115.

Use of X-ray methods has done much to advance knowledge of metals and alloys; nor can there be any doubt as to prospects of further progress along same road; at same time, this new weapon of research is at present very frequently handled by physicists, who are at times apt to ignore older methods of investigating metals and great mass of data which these have already established.

Evaluation of X-Ray Film Densograms in Cross-Section Diascopy of Metals and Alloys (Zur Kenntnis der Auswertung von Roentgenfilm-Densogrammen bei der Querschnitts-Diaskopie von Metallen und Legierungen), W. Claus. *Giesserei (Berlin)*, vol. 17, no. 31, Aug. 1, 1930, pp. 745-749, 13 figs.

Theoretical discussion of X-ray densograms of metals and alloys rendered homogeneous by working; densograms for cast structure of pure metals and alloys; densogram studies of cast tin bronzes, GBz 10.

Literature on the Use of the X-Ray, V. S. Polansky. *Heat Treating and Forging*, vol. 16, no. 8, Aug. 1930, pp. 1011-1014.

Bibliography of literature available in Carnegie Library of Pittsburgh up to May 1930 on X-ray examination of ferrous and metal alloys. (Continuation of serial.)

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